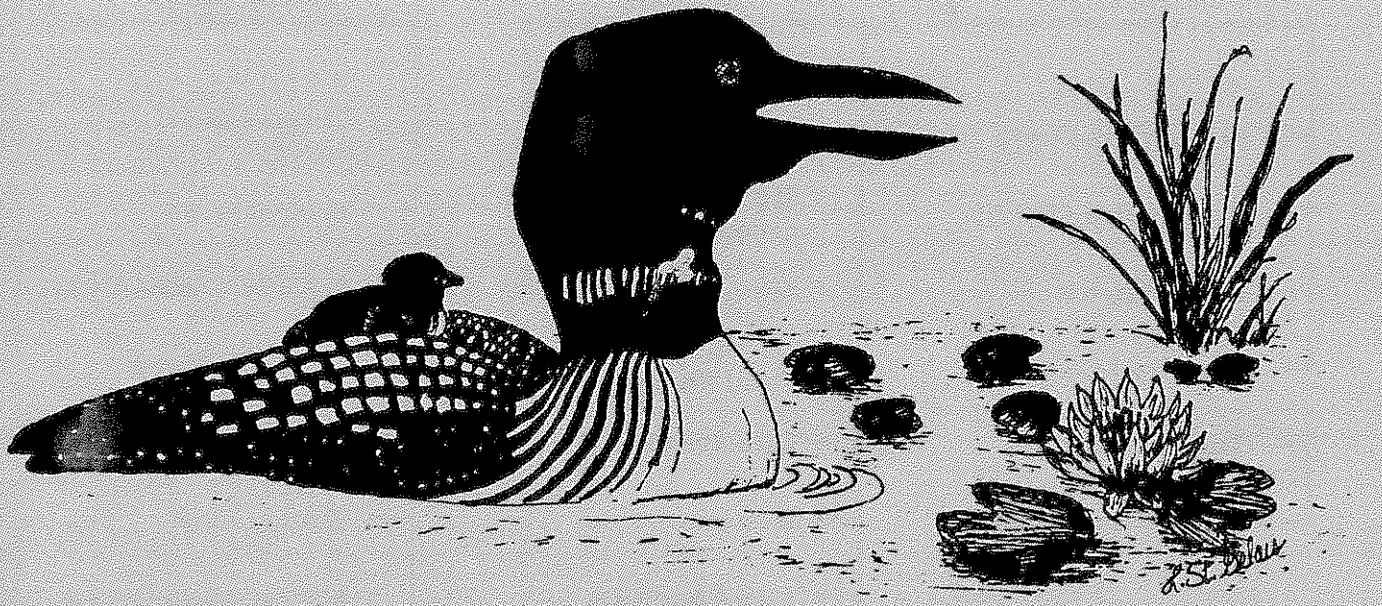
SILVER LAKE
1994
NH LAKES LAY MONITORING PROGRAM



NEW HAMPSHIRE LAKES LAY MONITORING PROGRAM

by
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edited by
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NH LLMP

FRESHWATER BIOLOGY GROUP
University of New Hampshire
Durham

UNIVERSITY OF NEW HAMPSHIRE COOPERATIVE EXTENSION
Helping You To Put Knowledge And Research To Work

To obtain more information about the NH Lakes Lay Monitoring Program (NH LLMP) contact the Coordinator (J.Schloss) at (603) 862-3848 Dr. Baker at 862-3845 or Dr. Haney at 862-2106

PARAMETERS SAMPLED

NH LAKES LAY MONITORING PROGRAM

LAY MONITORS

- **BASIC PROGRAM**
  - Secchi Disk Depth
  - Temperature Profile
  - Chlorophyll a
  - Dissolved Color
  - Total Alkalinity
  - Total Phosphorus
- **ADVANCED OPTIONS**
  - pH
  - Metalimnetic Chlorophyll a
  - Specific Conductivity
  - Hypolimnetic Total Phosphorus
  - Dissolved Oxygen
  - Bacteria
  - Fish Condition
  - Rainfall & pH
  - Aquatic Vegetation Surveys
  - Motorboat Effects
  - Watershed NPS Surveys
  - Road Salt Runoff
- **STREAM MONITORING**
  - Observational Surveys
  - Temperature
  - Specific Conductivity
  - Total Alkalinity
  - Total Phosphorus
  - Stream Flow
  - Macro-Invertebrates
  - Storm Event Sampling
  - Bacteria

Freshwater Biology Group (FBG) corroboration with the lay monitor data includes assessment of 1) physical parameters (water transparency, temperature profiles, light transmission profiles and water color); 2) chemical parameters (dissolved oxygen profiles, "free" carbon dioxide, total alkalinity, pH, total phosphorus and specific conductivity profiles); 3) biological parameters (chlorophyll a, phytoplankton community and zooplankton community). Note: in addition to the above parameters, other measurements are often collected at the discretion of the FBG or at the request of the lake association.

PREFACE

This report contains the findings of a water quality survey of Silver Lake, Madison, New Hampshire, conducted in the summer of 1994 by the **Freshwater Biology Group (FBG)** of the University of New Hampshire and the Silver Lake Association.

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1994 results as well as more detailed "Introduction" and "Discussion" sections. Graphic display of data is included, in addition to listings of data in appendices, to aid visual perspective.

ACKNOWLEDGMENTS

1994 was the twelfth year of participation in the **Lakes Lay Monitoring Program (LLMP)** for the Silver Lake monitors. The Lay Monitors of Silver Lake were Bob Benford, Ed and Pat Blackey, Pricilla Furse, Bruce Gordon, Frannie and Raymond Kennett, Robert Newton and Martha and Robert Risch.. Bruce Gordon and Bob Benford again coordinated the volunteer monitoring effort on Silver Lake and acted as liaisons to the Freshwater Biology Group **(FBG)**. **The Freshwater Biology Group** congratulates the Lay Monitors on the quality of their work, and the time and effort put forth. We encourage other interested citizens to join the monitoring effort on Silver Lake in 1995. Funding for the monitoring program was provided by the Silver Lake Association.

The **Freshwater Biology Group** is a not-for-profit research program co-directed by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the **FBG** summer field team included, Robert Craycraft (laboratory and field coordinator), Neim Hoang Dang, Tracy Grazia, Sean Proll and John Raifsnider. Other **FBG** staff assisting in the fall included Jessica Chappel and Rick Falzone while Lisa St. Gelais helped design our 1994 report format and the 1994 report cover.

The **FBG** acknowledges the University of New Hampshire Cooperative Extension for funding and furnishing office, laboratory and storage space. The College of Life Sciences and Agriculture provided accounting support and the UNH Office of Computer Services provided computer time and data storage allocations.

Participating groups in the **LLMP** include: The Center Harbor Bay Conservation Commission, Dublin Garden Club, Governor's Island Club Inc., Meredith Bay Rotary Club, The New Hampshire Audubon Society, Society for Protection of Lakes and Streams, Walker's Pond Conservation Society, United Associations of Alton, the associations of Baboosic Lake, Berry Bay, Bow Lake Camp Owners, Caanan Street, Canobie Lake, Chalk Pond, Chesham Pond, Lake Chocorua, Cunningham Pond, Crystal Lake, Dublin Lake, Glines Island, Goose Pond, Great East Lake, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Lovell Lake, March's Pond, Mendum's Pond, Merrymeeting Lake, Milton Ponds Lake Lay Monitoring, Mirror Lake (Tuftonboro), Moultonborough Bay, Lake Winnipesaukee, Naticook Lake, Newfound Lake, Nippo Lake, Pea Porridge Pond, Pemaquid Watershed, Silver Lake (Madison), Silver Lake (Tilton), Squam Lakes, Sunset Lake, Wentworth Lake and the towns of Alton, Amherst, Enfield, Errol, Madison, Meredith, Merrimack, Milan, Strafford and Wolfeboro.

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National Citizens' Volunteer Monitoring Conference held last April in Portland, Oregon. We were also invited to highlight our **NH LLMP** Cooperative Extension relationship at a southeast regional meeting for US Department of Agriculture water quality staff held in Florida. On the local front, the NH Senate Agricultural and Environment committee and the NH House Resource, Recreation and Development Committee were briefed on **NH LLMP** activities. We continue to be listed as a model citizen monitoring program on the Environmental Success Index of Renew America and on the Environmental Network Clearinghouse and were recently acknowledged by the National Awards Council for Environmental Sustainability. To date, the approach and methods of the **NH LLMP** have been adopted by new or existing programs in twenty two states and nine countries!

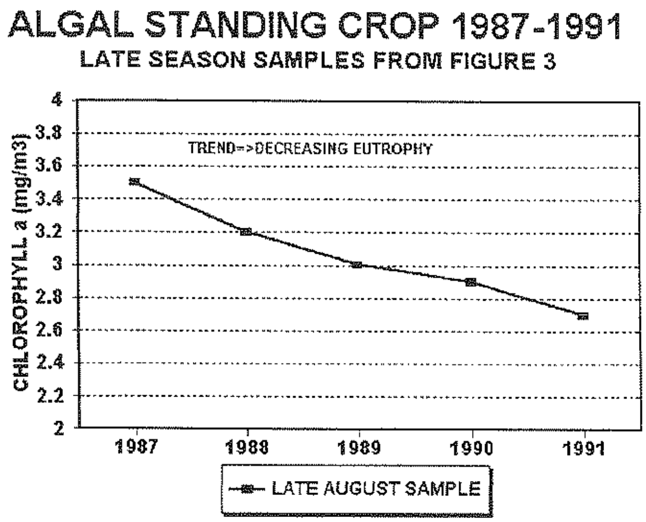
Importance of Long-term Monitoring

A major goal of a monitoring program is to identify any short or long-term changes in the water quality of the lake. Of major concern is the detection of cultural eutrophication: increases in the productivity of the lake, the amount of algae and plant growth, due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern, as New Hampshire receives large amounts of acid precipitation, yet most of our lakes contain little mineral content to neutralize this type of pollution.

For almost a decade and a half, data collected weekly from lakes participating in the New Hampshire Lakes Lay Monitoring Program have indicated there is quite a variation in water quality indicators through the open water season on the majority of lakes. Short-term differences may be due to variations in weather, lake use, or other chance events. Monthly sampling of a lake during a single summer provides some useful information, but there is a greater chance that important short-term events such as algal blooms the lake response to storm run-off will be missed. These short-term fluctuations may be unrelated to the actual long-term trend of a lake or they may be indicative of the changing status or "health" of a lake.

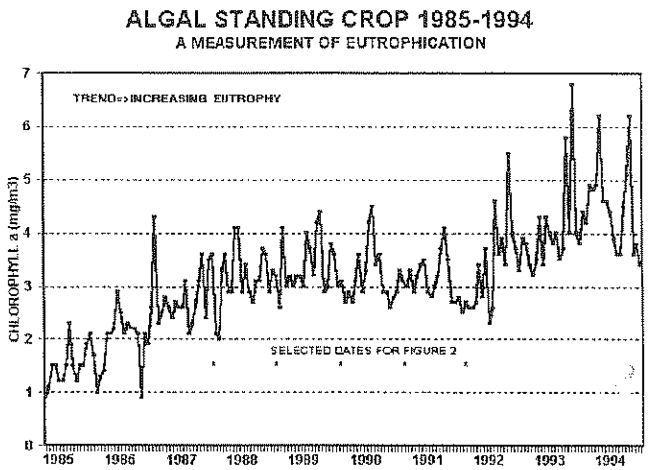
To determine if a change in water quality is occurring, a lake must be sampled on a frequent basis over a substantial amount of time. A poorly designed sampling program may even mislead the investigator away from the actual trend: Consider the hypothetical lake in Figure 2. Sampling only once a year during August from 1987 to 1991 would produce a plot (Fig. 2) suggesting a decrease in eutrophication. The actual

Figure 2.



long-term trend of the lake, increasing eutrophy, can only be clearly discerned by sampling additional times a year for a ten year period (Fig. 3). Frequent monitoring carried out over the course of many summers can provide the information required to distinguish between short-term fluctuation ("noise") and long-term trends ("signal"). To that end, the lake must establish a long-term data base.

Figure 3.



The number of seasons it takes to distinguish between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long-term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. In addition, different areas of a lake may show a different response. As more data is collected, prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of the lake.

There are also short-term uses for lay monitoring data. The examination of different stations in a lake can disclose the location of specific problems and corrective action can be initiated to handle the situation before it becomes more serious. On a lighter note, some associations post their weekly data for use in determining the best depths for finding fish!

It takes a considerable amount of effort as well as a deep concern for one's lake to be a lay monitor in the **NH Lakes Lay Monitoring Program**. Many times a monitor has to brave inclement weather or heavy boat traffic to collect samples. Sometimes it even may seem that one week's data is just the same as the next. Yet every sampling provides important information on the variability of the lake.

We are pleased with the interest and commitment of our Lay Monitors and are proud that their work is what makes the **NH LLMP** the most extensive, and we believe, the best volunteer program of its kind.

Purpose and Scope of This Study

1994 was the twelfth year that monitoring of Silver Lake was undertaken by the **Freshwater Biology Group** and the Silver Lake Association. The monitoring program was designed to continue adding data to the long-term data base established. Sampling emphasis was placed on six open water deep stations while additional tributary sampling was also undertaken.

The primary purpose of this report is to discuss results of the 1994 monitoring season with emphasis on current conditions of Silver Lake including the extent of eutrophication and the lake's susceptibility to increasing acid precipitation. This information is part of a large data base of historical and more recent data compiled and entered onto computer files for New Hampshire lakes that include New Hampshire Fish and Game surveys of the 1930's, the surveys conducted by the New Hampshire Water Supply and Pollution Control Commission and the **FBG** surveys. However, care must be taken when comparing current results with early studies. Many complications arise due to methodological differences of the various analytical facilities and technological improvements in testing.

INTRODUCTION

The New Hampshire Lakes Lay Monitoring Program

1994 marked the seventeenth year of operation for the **NH Lakes Lay Monitoring Program (LLMP).** The **LLMP** has grown from a university class project on Chocorua Lake and pilot study on the Squam Lakes to a comprehensive state-wide program with over 500 volunteer monitors and more than 100 lakes participating. Originally developed to establish a data-base for determining long-term trends of lake water quality for science and management, the program has expanded by taking advantage of the many resources that citizen monitors can provide. The **NH LLMP** has an international reputation as a successful cooperative monitoring, education and research program. Current projects include: use of volunteer generated data for non-point pollution studies using high tech analysis system (Geographic Information Systems and Satellite Remote Sensing), intensive watershed monitoring for the development of lake nutrient budgets, and investigations of water quality and indicator organisms (food web analysis, fish condition, and stream invertebrates). The key ingredients responsible for the success of the program include innovative funding and cost reduction, assurance of credible data, practical sampling protocols and, most importantly, the interest and motivation of our volunteer monitors.

The 1994 sampling season was another exciting year for the **New Hampshire Lakes Lay Monitoring Program**. National recognition for the high quality of work by you, the volunteer monitors, continued with awards, requests for program information and invitations to speak at national conferences (Figure 1). Our Geographic Information System study of Squam Lake was highlighted at the Fourth

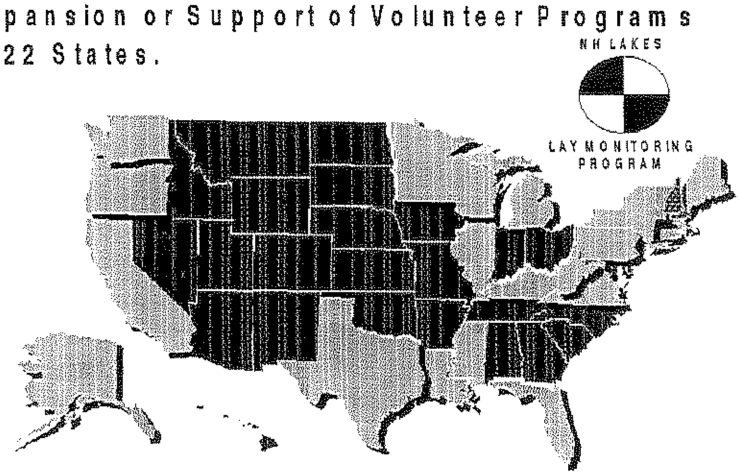
Figure 1. Awards and Recognition.

AWARDS

and

1983 - NH Environmental Law Council
1984 - Governor's Volunteerism Award
1985 - CNN Science & Technology Today
1988 - Governor's 'Gift' request funded
1990 - New Hampshire Journal on PBS
1991 - Renew America Success Award
- Environmental Success Index
- UN Environmental Programme
- Soviet Embassy Reception
- White House Environment Briefing
1992 - EPA Administrators Award
- Environmental Exchange Network
1993 - NH Lakes Association
1994 - Fourth National Citizens' Volunteer Monitoring Conference

NH LLMP Directly Involved with the Initiation, Expansion or Support of Volunteer Programs in 22 States.



The General Scenario - 1994

1994 Climatic Summary

The winter of 1993-94 was one of the colder on record and included above average precipitation during the winter season. Snowfall was particularly plentiful in the months of January and March when major snowstorms made their way through New Hampshire. The accumulated snowpack resulted in considerable runoff in late March and Early April during the spring snowmelt. For those lakes which were monitored early enough, the winter conditions translated into lower alkalinities (buffering capacities) and lower pH levels in the tributary streams and in some lakes, when compared to results from a few years back; years with little snow pack. Thus, while many lakes had steady or even increasing buffering levels during dry winters (winters with below average snowfall), the heavy snowfall during the winter of 1993-94 indicates that acid rain should still be on of our concerns.

Below average rainfall was documented during the spring months of April and June while the month of May was wetter than normal. The month of July was off to a wet start with precipitation levels exceeding the norm by over one inch, followed by a dry month of August which demonstrated below average rainfall of over one inch, and once again a wetter than normal month in September. The 1994 precipitation levels (through September) were above normal while short term dry spells were encountered; particularly in February, June and August. The summer months were also characterized by a number of localized rainstorms which passed through New Hampshire. Thus, while the general precipitation scenario, described above, summarizes the 1994 precipitation data, the locality of daily precipitation events was highly variable and might not characterize the conditions around your lake.

The 1994 temperature patterns also had an effect on water quality. The below average temperatures in January, February and March maximized snowpack retention until late March when temperature exceeded 32° Fahrenheit and considerable watershed runoff occurred. The temperatures were more characteristic of the normal conditions in April and May while the month of June was characterized by above average temperatures. The above average temperatures in June resulted in the rapid surface water (epilimnetic) warming which is conducive to algal, aquatic plant and bacterial growth. Additional factors which stimulated the elevated algal, aquatic plant and bacterial growth included the influx of nutrients during summer storm events, greater sunlight penetration during clear days, lower lake levels during short term dry spells, as well as, the mobilization of deep-water algal populations into the surface waters and increased growth rates during optimal conditions (discussed below). The above average temperatures, conducive to primary productivity, persisted through July but dipped to near average and below average levels in August and resulted in surface water cooling in our New Hampshire lakes which continued into the fall months.

1994 Water Quality Observations

Reduced Secchi Disk transparency readings, relative to 1993, were characteristic of most Hampshire Lakes during the 1994 sampling season. Lakes were less clear due to a combination of factors that included increased dissolved color compounds (dissolved organic matter from the breakdown of vegetation and soils) washed in from surrounding wetland areas, higher algal growth (measured as chlorophyll *a*) in the surface waters, due to increased nutrient runoff and greater suspended sediment levels transported into the lake during storm events and increased bacterial growth. Dissolved water color is not indicative of water quality problems (although large increases in dissolved color sometimes follow large land clearing operations) but in some of our more pristine program lakes, it nevertheless has a large effect on water clarity changes. Likewise, elevated bacterial densities are not necessarily indicative of water quality problems as the majority of these organisms (heterotrophic, not pathogenic) are a natural component of even our cleanest lakes. However, these small organisms can have a profound effect on water quality as they can rapidly absorb and redirect light which will in turn diminish our Secchi Disk readings. If fecal contamination is suspected, future monitoring can include the collection of indicator bacteria data (i.e. E Coli; the New Hampshire indicator bacteria).

As with dissolved color and nutrients, the wet spring brought a greater suspended sediment load to many of our streams and lakes during that period while short term summer storm events resulted in additional sedimentation. If decreased clarity was not the result of increased dissolved color or chlorophyll *a* levels than it was likely due to increased suspended sediment by default. To find out how these water quality indicators inter-relate for Silver Lake, compare the Secchi Disk, chlorophyll *a* and dissolved color graphs enclosed in this report (see figures 6-23). Note whether changes in clarity (secchi disk depth) correspond to chlorophyll *a* or dissolved color concentration changes or whether it is a combination of the two. If neither seem to exhibit a consistent effect, then suspended sediment likely plays an important role in your lake's clarity.

Several lakes experienced "algal blooms" during the 1994 sampling season. "Algal blooms" are often "green water events" associated with decreases in water clarity due to their ability to absorb and scatter light within the water column, but can also accumulate near the lake bottom in shallow areas as "mats" or on the water surface as "scums" and "clouds". All types of "algal blooms" were observed in several participating **LLMP** lakes in 1994. The occasional formation of certain "algal blooms" are naturally occurring phenomenon and are not necessarily associated with changes in lake productivity. Increases in the occurrence of "bloom" conditions can be a sign of eutrophication (the "greening" of a lake). Algal blooms of varied extent typically occur even in our most pristine lakes late in the fall and early in the spring as a result of lake mixing, which resuspends nutrients, at those times.

In many lakes, particularly those within the Lakes Region of New Hampshire, cotton-candy like "clouds" of the nuisance green filamentous algae, *Mougeotia*, or a related species formed within the weed beds and then drifted freely into shallow areas around the lake. These algae often take advantage of nutrients that leak from particularly active submerged weeds or from bottom areas that have been disturbed by weed removal or other activities.

For some lakes, weather conditions became conducive to the formation of "blooms" of other algae species during the summer months when the water temperatures were above average. Unlike 1993, when the algal blooms were short term events (spanning less than a week), the blooms persisted for greater than a month in a handful of sampled lakes. In those lakes which experienced long term algal blooms the types of algae tended to be of the nuisance blue-green bacterial variety (formerly referred to as blue-green algae) and included such nuisance forms as *Anabaena, Lyngbya* and *Merismopedia.*

In other lakes, metalimnetic algae, algae which tend to grow in a thin layer along the thermocline gradient in a lake's middle depths, sometimes migrate up towards the lake surface causing a "bloom" event. If these algae are predominantly "nuisance" forms, like certain green or blue-green algae, they can be an early indication nutrient loading. The **LLMP** will continue to monitor "bloom" phenomenon in 1995 as it can be a sign of the changing land use practices and impacts within the lake watershed that can result in a long-term increase in lake productivity. Future monitoring will continue to monitor the frequency of algal blooms in our New Hampshire lakes' and discern whether or not they are signs of short-term perturbations in water quality, the "noise" within the true long-term signal, induced by the weather conditions of this past summer.

SILVER LAKE
1994 NON-TECHNICAL SUMMARY

Bi-weekly sampling of the Silver Lake deep sampling stations, Sites 1 South, 2 Deep, 3 Center, 4 East, 5 North and 7 North Island, was undertaken by the volunteer monitors from June 9 through September 28 (see Appendix A). The following section summarizes the 1994 water quality conditions for Silver Lake and when applicable, incorporates historical data into the interpretation.

1) Secchi Disk transparency data (a measure of water clarity) collected by the Silver Lake volunteer monitors were high in 1994 and averaged 7.4 meters (24.1 feet) at Site 1 South, 7.2 meters (23.4 feet) at Site 2 Deep, 7.3 meters (23.7 feet) at Site 3 Center, 6.0 meters (19.5 feet) at Site 4 East, 6.6 meters (21.5 feet) at site 5 North and 5.8 meters (18.9 feet) at Site 7 North Island. Transparency values greater than 4 meters are typical of a clear, unproductive, lake while transparency values less than 2.5 meters are generally an indication of a highly productive lake. Secchi Disk readings between 2.5 and 4.0 meters are considered indicative of a moderately productive lake.

In general, the 1994 water clarity measurements were high and typical of an unproductive lake. However, the seasonal average Secchi Disk transparencies decreased in Silver Lake (see figures 24, 26, 28, 31 and 34). Reduced water clarity was most evident at Site 7 North Island where the seasonal average Secchi Disk transparency declined by 0.9 meters relative to 1993. Note: Secchi Disk comparisons are not included for Site 4 East due to the Secchi Disk reaching the lakebottom before disappearing from view.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) collected by the Silver Lake volunteer monitors were low in 1994. The seasonal chlorophyll *a* concentration averaged 1.1 milligrams per cubic meter (1.1 mg m^{-3} equivalent to 1.1 parts chlorophyll *a* per billion parts water) at Site 1 South, 1.0 mg m^{-3} at Site 2 Deep, 1.0 mg m^{-3} at Site 3 Center, 1.2 mg m^{-3} at Site 4 East, 1.4 mg m^{-3} at Site 5 North and 1.3 mg m^{-3} at Site 7 North Island. Chlorophyll *a* concentrations below 3 mg m^{-3} are common to an unproductive lake while chlorophyll *a* concentrations above 7 mg m^{-3} are common to a productive lake. Chlorophyll *a* concentrations between 3 mg m^{-3} and 7 mg m^{-3} are considered characteristic of a moderately productive lake.

The 1994 seasonal average chlorophyll *a* concentrations were similar to the 1993 seasonal average levels (see figures 25, 27, 29, 30, 32 and 34). All surface water chlorophyll *a* data collected in 1994 remained below the concentration of 3 mg m^{-3} considered the boundary between an unproductive and moderately productive lake.

3) The seasonal average dissolved lakewater color levels were low to moderate, 22.5 platinate color units (ptu), and less than the seasonal average of 25.7 ptu for **LLMP** lakes. Dissolved, color, or true color as it is sometimes

called, is indicative of dissolved organic carbon levels in the water (a by-product of microbial decomposition). Small increases in water color from the natural breakdown of plant materials in and around a lake are not considered to be detrimental to water quality. However, increased color can lower water transparency, and hence, change the public perception of water quality, as well as, mask the ability of the Secchi Disk transparency to predict chlorophyll levels. Large amounts of dissolved color might occur naturally but can also occur during deforestation and development within the watershed. Dissolved color data collected by the **NH LLMP** volunteer monitors over the past nine years indicate dissolved color concentrations are higher during wet years (years with above average precipitation), when precipitation events flush highly colored waters into the lake from the watershed.

The 1994 Silver Lake seasonal average dissolved color concentration is about 5.1 color units higher than the 1993 seasonal average of 17.4 ptu. While dissolved color levels are not considered detrimental to water quality, the higher dissolved color levels documented in 1994 suggest increased watershed runoff that can carry with it sediment particles as well as nutrients (including the limiting nutrient; phosphorus). Increased nutrient inputs will stimulate algal growth while the combination of elevated suspended sediment levels and elevated dissolved color concentrations will diminish water clarity readings (note the reduction of water clarity across Silver Lake). Of particular interest is the northern site, 7 North Island, where the Secchi Disk transparency decreased considerably yet the chlorophyll *a* concentration remained unchanged and the dissolved color concentration increased only slightly. The 7 North Island data suggest the effect of suspended sediment on this site. Future sampling should focus on the Forrest Inlet that is the most likely source of sediment loading.

4) Total phosphorus (generally considered the limiting nutrient for plant growth in freshwater systems) concentrations, collected in the surface waters, were low to moderate when sampled by the **FBG** and volunteer monitors (range: 3.1 to 12.6 parts per billion). Bottom water (hypolimnetic) total phosphorus concentrations were low at the 2 Deep (5.6 ppb) and 5 North (8.7 ppb) sampling stations but reached the moderate concentration of 15.0 ppb at the 7 North Island site. Total phosphorus samples, collected in the Cooks Inlet (4.6 ppb), Deer River (7.9 ppb), and Forrest Inlet (5.1 ppb) were low and remained below the concentration of 15 ppb that is considered sufficient to cause an algal bloom.

5) Specific conductivity (an indicator of dissolved salt content) of the Silver Lake deep sampling stations was low and ranged from 32.4 to 32.8 micro-Siemans (*u*S) at Site 2 Deep, ranged from 32.5 to 33.3 *u*S at Site 5 North and ranged from 32.9 to 34.3 *u*S at Site 7 North Island (see Appendix A). High conductivity values can be an indication of failing septic systems, fertilizer use and/or road salt runoff.

6) The alkalinity (a measure of resistance to acidification) of the lake is low, 3.0 units, and about 3 units lower than the average of 6.3 units for **LLMP** program lakes. The 1994 seasonal average alkalinity is about 1 unit lower than the 1994 seasonal average alkalinity of 4.0 units and might be attributable to the above average precipitation in 1994, that often brings with it an acidic component capable of reducing the lake's alkalinity. PH measurements collected by the **FBG** (August 10) indicate the pH

levels remain within the tolerable range for most aquatic organisms.

7) Temperature profiles collected by the volunteer monitors indicate the upper mixed layer of water (epilimnion) extended to about 6.0 meters (19.5 feet) during the 1994 sampling season. The formation of thermal stratification limits water circulation that can favor anoxic conditions in the deeper waters. Low dissolved oxygen concentrations can be stressful to fish and other aquatic organisms and can favor the release of nutrients from the lake sediments. Low dissolved oxygen concentrations near the lakebottom suggest accumulating organic matter from both internal (i.e. algal and plant growth) and external sources (i.e. grass clipping and leaf litter).

Dissolved oxygen data collected by the **FBG** (August 10, 1994) indicate the dissolved oxygen concentration remained above 5 milligrams per liter (the minimum oxygen concentration required for the successful growth and reproduction of most coldwater fish) down to the lakebottom of Sites 2 Deep and 5 North but only down to about 8.5 meters at Site 7 North Island. Elevated phosphorus concentrations were documented near the lakebottom of Site 7 North Island and suggest internal nutrient loading (nutrients released from the lakebottom). Historically, a sawmill was located along the shoreline near the 7 North Island sampling site that would have contributed to the organic load (i.e. sawdust) and result in lower dissolved oxygen concentrations near the lakebottom. However, this site is close proximity to the Forrest Brook inlet and will be further impacted by organic matter loading and other inputs (i.e. nutrients) from the stream.

8) The bi-weekly chlorophyll *a* data and weekly sampling of Secchi Disk data collected by the Silver Lake volunteer monitors are indicative of an unproductive New Hampshire lake. However, the northern Silver Lake sampling stations; Sites 5 North and 7 North Island, continue to exhibit a higher level of lake productivity than the other (southerly) Silver Lake sampling stations.

COMMENTS AND RECOMMENDATIONS

1) We recommend that each participating association, including the Silver Lake Association, continue to develop its data base on lake water quality through continuation of the long term monitoring program. The data base will provide information on the short and long-term cyclic variability that occurs in the lake and will eventually enable more reliable predictions of water quality trends.

2) We recommend initiating lake sampling early in the season (April/May) to document the lake's reaction to the nutrient and acid loadings that typically occur during and after spring thaw. Emphasis should be placed on chlorophyll *a* and alkalinity sampling, as the spring runoff can have a profound effect on these parameters (i.e. increased algal growth and lower alkalinity levels). Phosphorus samples are also recommended from both the in-lake and the tributary sampling sites. When tributary samples are collected, stream flow measurements should be included. Contact the **LLMP** for more information on collecting streamflow measurements.

3) Changing land use within the Silver Lake watershed, the surrounding land that drains into the lake, can accelerate the natural aging process. A typical lake fills in and becomes more productive on a geological time frame (thousands of years), however, this process can be accelerated and occur in tens of years when development, agriculture and other landscape changes occur that do not incorporate best management practices (i.e. maintaining vegetative buffer strips along the shoreline, minimizing fertilizer and pesticide applications, installing proper erosion control structures, etc.) that are set up to minimize water quality impacts. We invite interested persons to take part in a new assessment manual, produced jointly by the **UNH LLMP** and the **Natural Resource Conservation Service** (formerly the New Hampshire Soil Conservation Service), which provides the layperson with a systematic method for recognizing and evaluating erosion, sedimentation and related non-point source (NPS) pollutant problems in New Hampshire watersheds. Contact the **LLMP** coordinator for further information.

DISCUSSION OF LAKE MONITORING MEASUREMENTS

The section below details the important concepts involved for the various testing procedures used in the **New Hampshire Lakes Lay Monitoring Program**. Where appropriate, summary statistics of 1994 results from all participating lakes are included. Certain tests or sampling performed at the time of the optional **Freshwater Biology Group** field trip are indicated by an asterisk (*).

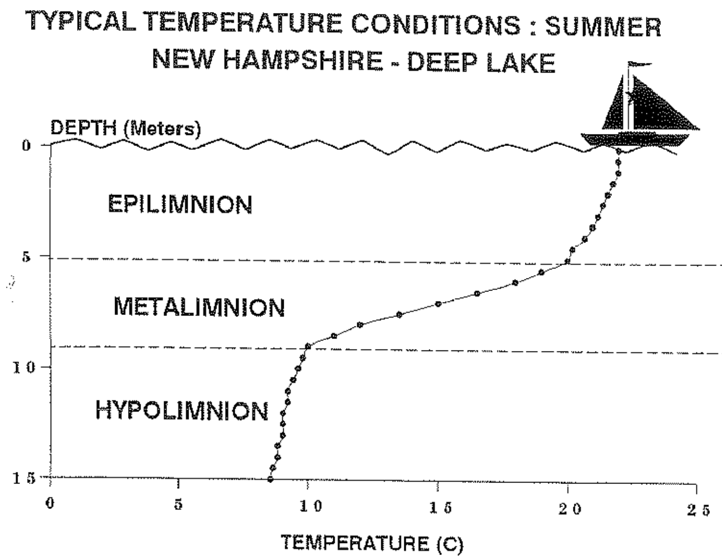
Thermal Stratification in the Deep Water Sites

Lakes in New Hampshire display distinct patterns of temperature stratification, that develop as the summer months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water (**hypolimnion**). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the **thermocline** or **metalimnion** (figure 4). Some shallow lakes may be continually mixed by wind action and will never stratify. Other lakes may only contain a developed epilimnion and metalimnion.

Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of secchi disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

Figure 4.



In the shallow areas of many lakes, the secchi disk will hit bottom before it is able to disappear from view (what is referred to as a "Bottom Out" condition). Thus, Secchi disk measurements are generally taken over the deepest sites of a lake. Transparency values greater than 4 meters are typical of clear, less productive lakes while transparency values less than 2.5 meters are generally an indication of highly productive lakes. Water transparency values between 2.5 meters and 4 meters are generally considered indicative of moderately productive lakes. In 1994 the average transparency for lakes participating in the **NH LLMP** was 5.6 meters with a range of 0.3 to

10.7 meters. Refer to table 1 for a summary of the 1994 Silver Lake Secchi Disk transparency data.

Table 1. 1994 Lay Monitor Secchi Disk Data comparison of Silver Lake.

Site	Transparency (m) Minimum	Transparency (m) Average	Transparency (m) Maximum	Sample Size
1 South	5.5	7.4	9.0	15
2 Deep	6.5	7.2	8.2	15
3 Center	5.8	7.3	10.1	15
4 East	5.0	6.0	6.2	15
5 North	5.4	6.6	7.5	15
7 North Isl	4.5	5.8	7.6	14

Chlorophyll *a*

The chlorophyll *a* concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Characteristics include accumulated organic matter in the lake basin and lower dissolved oxygen in the bottom waters. Summer chlorophyll *a* concentrations average above 7 mg m^{-3} (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll *a* concentrations are generally less than 3 mg m^{-3}. These lakes generally have cleaner bottoms and high dissolved oxygen levels throughout. **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll *a* generally between 3 mg m^{-3} and 7 mg m· In 1994, the average chlorophyll *a* concentration for lakes participating in the **NH LLMP** was 3.3 mg m^{-3} with a range of 0.4 to 58.1 mg m^{-3}. Refer to table 2 for a summary of the 1994 Silver Lake chlorophyll *a* data.

Table 2. 1994 Lay Monitor Chlorophyll *a* Data comparison of Silver Lake.

Site	Chl *a* (ppb) Minimum	Chl *a* (ppb) Average	Chl *a* (ppb) Maximum	Sample Size
1 South	0.6	1.1	1.6	8
2 Deep	0.6	1.0	1.6	8
3 Center	0.7	1.0	1.6	8
4 East	0.9	1.2	1.4	8
5 North	0.8	1.4	2.7	8
7 North Isl	0.8	1.3	1.6	8

Testing is sometimes done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentrations of a water sample collected in the thermocline is compared to the integrated epilimnetic sample. Greater chlorophyll levels of the point sample, in conjunction with microscopic examination of the samples (see Phytoplankton section below), confirm the presence of such a population of algae. se populations should be monitored as they may be an indication of increased nutrient loading into the lake.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from **humic substances**, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters. Increases in dissolved watercolor can be an indication of increased development within the watershed as many land clearing activities (construction, deforestation, and the resulting increased run-off) add additional organic material to lakes. Natural fluctuations of dissolved color occur when storm events increase drainage from wetlands areas within the watershed. As suspended sediment is a difficult and expensive test to undertake, <u>both</u> dissolved color and chlorophyll information is important when interpreting the secchi disk transparency

Dissolved color is measured on a comparative scale that uses standard chloroplatinate dyes and is designated as a color unit or ptu. Lakes with color below 10 ptu are very clear, 10 to 20 ptu are slightly colored, 20 to 40 ptu are lightly tea colored, 40 to 80 ptu are tea colored and greater than 80 ptu indicates highly colored waters. Generally the majority of New Hampshire lakes have color between 20 to 30 ptu. In 1994 the average dissolved color for participating **NH LLMP** lakes was 25.7 ptu with a range of 2.6 to 371.1 ptu. Refer to table 3 for a summary of the 1994 Silver Lake dissolved color data.

Table 3. 1994 Lay Monitor Dissolved Color Data comparison of Silver Lake.

Site	Color (ptu) Minimum	Color (ptu) Average	Color (ptu) Maximum
1 South	15.5	21.3	27.5
2 Deep	14.6	22.2	36.9
3 Center	13.7	21.6	25.8
4 East	18.0	24.6	30.1
5 North	15.5	21.2	26.6
7 North Isl	15.5	23.7	36.9

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 15 parts per billion of phosphorus in a lake can cause an algal bloom.

Generally, in the more pristine lakes, phosphorus values are higher after spring melt when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants which in turn die and sink to the lake bottom causing phosphorus to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (Agriculture, Sediment Erosion, Septic Systems, etc.) will show greater concentrations of nutrients as the summer progresses or after major storm events. Circulation of nutrients from the bottom waters of more productive lakes in late fall can result in algal blooms.

pH *

The pH is a way of expressing the acidic level of lake water, and is generally measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (i.e.: changes in 1 pH unit reflect a ten times difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock and soils of lake watersheds.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada by Schindler, gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

The analysis of alkalinity employed by the **Freshwater Biology Group** includes use of a dilute titrant allowing an order of magnitude greater sensitivity and precision than the standard method. Two endpoints are recorded during each analysis. The first endpoint (gray color of dye; pH endpoint of 5.1) approximates low level alkalinity values, while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically, such as NH Fish and Game data, with the methyl-orange endpoint method.

The average alkalinity of lakes throughout New Hampshire is low, approximately 9 mg per liter (calcium carbonate alkalinity), while the average alkalinity of the lakes studied by the **Freshwater Biology Group** in the **NH LLMP** is approximately 6.3 mg per liter. When alkalinity falls below 2 mg per liter the pH of waters can greatly fluctuate. Alkalinity levels are most critical in the spring when acid loadings from snowmelt and run-off are high, and many aquatic species are in their early, and most susceptible, stages of their life cycle.

Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Fertilizers and other pollutants can also increase the conductivity of the water. Conductivity is measured in micro**mhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans.

Dissolved Oxygen and Free Carbon Dioxide *

Oxygen is an essential component for the survival of aquatic life. Submergent plants and algae take in free carbon dioxide and create oxygen through **photosynthesis** by day. **Respiration** by both animals and plants uses up oxygen continually and creates **carbon dioxide**. Dissolved oxygen profiles determine the extent of declining oxygen concentrations in the lower waters. High carbon dioxide values are indicative of low oxygen conditions and accumulating organic matter. For both gases, as the temperature of the water decreases, more gas can be dissolved in the water.

The typical pattern of clear, unproductive lakes is a slight decline in hypolimnetic oxygen as the summer progresses. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter (parts per million) in the cool deep waters. On the other hand, carp and catfish can survive very low oxygen conditions. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter. In some lakes, anoxic conditions near the lakebottom can lead to significant internal nutrient loading (the release of nutrients from the sediments).

Bacteria, fungi and other **decomposers** in the bottom waters break down organic matter originating from the watershed or generated by the lake. This process uses up oxygen and produces carbon dioxide. In lakes where organic matter accumulation is high, oxygen depletion can occur. In highly stratified eutrophic lakes the entire hypolimnion can remain unoxygenated or **anaerobic** until fall mixing occurs.

The oxygen peaks occurring at surface and mid-lake depths during the day are quite common in many lakes. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of photosynthesis, collecting in regions of high algal concentrations. If the peak occurs in the thermocline of the lake, metalimnetic algal populations (discussed above) may be present.

Underwater Light *

Underwater light available to photosynthetic organisms is measured with an **underwater photometer** which is much like the light meter of a camera (only waterproofed !). The **photic zone** of a lake is the volume of water capable of supporting photosynthesis. It is generally considered to be delineated by the water's surface and the level where light is reduced, by the absorption and scattering properties of the lake water, to one percent of the surface intensity. The one percent depth is sometimes termed the **compensation depth**. Knowledge of light penetration is important when considering lake productivity and in studies of submerged vegetation. Discontinuity (abrupt changes in the slope) of the profiles could be due to metalimnetic layering of algae or other particulates (discussed above). The underwater photometer allows the investigator to measure light at depths below the Secchi disk depth to supplement the transparency information.

Indicator Bacteria *

Coliform bacteria in water indicate the possibility of fecal contamination. Although they are usually considered harmless to humans, they are much easier to test for than harmful pathogenic enteric bacteria (**Salmonella**, **Shigella** etc.) and viruses that may be present in fecal material. **Total coliform** includes all coliform bacteria which arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **Fecal streptococcus** (sometimes referred to as **enterococcus**) also can be monitored. The ratio of fecal coliform to fecal strep may be useful in suggesting the type of animal source responsible for the contamination. In 1991, the State of New Hampshire changed the indicator organism of preference to E. Coli which is a specific type of fecal coliform bacteria thought to be a better indicator of human contamination. The new state standard requires Class A bathing waters to be under 88 organisms per 100 milliliters of lakewater.

Ducks and geese are often a common cause of high concentrations of coliform at specific lake sites. While waterfowl are important components to the natural and aesthetic qualities of lakes that we all enjoy, it is poor management practice to encourage these birds by feeding them. The lake and surrounding area provides enough healthy and natural food for the birds and feeding them stale bread or crackers does nothing more than import additional nutrients into the lake and allows for increased plant growth. As birds also are a host to the parasite that causes "swimmers itch", waterfowl roosting areas offer a greater chance for infestation to occur. Thus while leaving offerings for our feathered friends is enticing, the results can prove to be detrimental to the lake system and to human health.

Phytoplankton *

The planktonic community includes microbial organisms that represent diverse life forms, containing photosynthetic as well as non-photosynthetic types, and including bacteria, algae, crustaceans and insect larvae (the zooplankton are discussed below in a separate section). Because planktonic algae or "phytoplankton" tend to undergo rapid seasonal cycles on a time scale of days and weeks, the levels of populations found should be considered to be most representative of the time of collection and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

The composition and concentration of phytoplankton can be indicative of the trophic status of a lake. Seasonal patterns do occur and must be considered. For example **diatoms**, tend to be most abundant in April-June and October-November, in the surface or epilimnetic layers of New Hampshire lakes. As the summer progresses, the dominant types might shift to **green algae** or **golden algae**. By late season **Blue-green bacteria** generally dominate. In nutrient rich lakes, nuisance green algae and/or bluegreen bacteria might dominate continually. After fall mixing diatoms might again be found to bloom.

Zooplankton *

There are three groups of zooplankton that are generally prevalent in lakes: the **protozoa**, **rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints usually make it necessary to sample only the larger zooplankton (macrozooplankton; larger than 80 or 150 microns; 1 million microns make up a meter). Thus, zooplankton analysis is generally restricted only to the larger crustaceans. Crustacean zooplankton are very sensitive to pollutants and are commonly used to indicate the presence of toxic substances in water. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods**.

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species might control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake. A healthy and diverse zooplankton population will allow for the most efficient cycling of materials in the lake ecosystem; keeping the phytoplankton population down and providing a food supply for the fish population.

As discussed above for phytoplankton, zooplankton undergo seasonal population cycles and the results discussed below are most representative of the collection dates and not necessarily of other times during the ice-free season, especially during the early spring and late fall.

Zebra Mussels

Zebra mussels (*Dreissena polymorpha*) are non-native, freshwater mollusks. Their shells are marked by varying patterns of alternating dark and light bands and they are typically less than two inches long. The veligers (larval form) are free swimming, nearly invisible, and profuse. The adults secrete strong byssal threads by which they attach and reattach themselves to a variety of surfaces. These threads allow them to colonize quickly and reach densities of 100,000 or more mussels per square yard. The mussels have an average lifespan of 3.5 to 5 years.

Zebra mussels originated in the drainage basins of the Black, Caspian, and Aral seas of eastern Europe and have been in northwestern freshwater since the 1700s. Since first being introduced to North America in 1986, zebra mussels have dramatically altered the balance of freshwater systems and fisheries. These small water dwelling animals have also caused millions of dollars in expenses for industrial water users, drinking water facilities, commercial and recreational boaters, farmers, and other groups and organizations in Canada and the Great Lakes region.

The range occupied by these unwelcome visitors has expanded and continues to grow rapidly. In North America, sightings have been recorded as far north as the Saint Lawrence River near Quebec, as far east as the lower portion of the Hudson River, as far south as the Mississippi River near Vicksburg, and as far west as the Arkansas River in Oklahoma.

In 1993, zebra mussel sightings were confirmed in New England (Lake Champlain). The Lake Champlain population has existed for at least two years, if not longer. Thus, New Hampshire residents and boaters are being encouraged to arm themselves with knowledge about the natural history and geographic spread of the mussels. Interstate boaters and anglers, in particular, should become familiar with boating and fishing practices that decrease the likelihood that zebra mussels will be transferred from an infested water body to an uninfested one.

The infestation risk factor for any particular water body is determined mainly by the amount and type of boat traffic it supports and the chemical characteristics and temperature it maintains. While the goal is to prevent the mussels from becoming established in New England waters, zebra mussels have proven to be adaptable creatures able to survive in a growing range of environmental conditions. Cooperative monitoring activities coordinated by the **New Hampshire Lakes Lay Monitoring Program** will help determine if and when zebra mussels become established in this region. If zebra mussels are found, information about control techniques can help those concerned choose the best method to reduce the destructive impacts of the mussels.

To receive more information, request an educational presentation for your next group meeting, become involved in monitoring efforts, or confirm an identification, contact:

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REPORT FIGURES

Figure 5. Location of the 1994 Silver Lake deep and tributary sampling stations, Madison, New Hampshire.

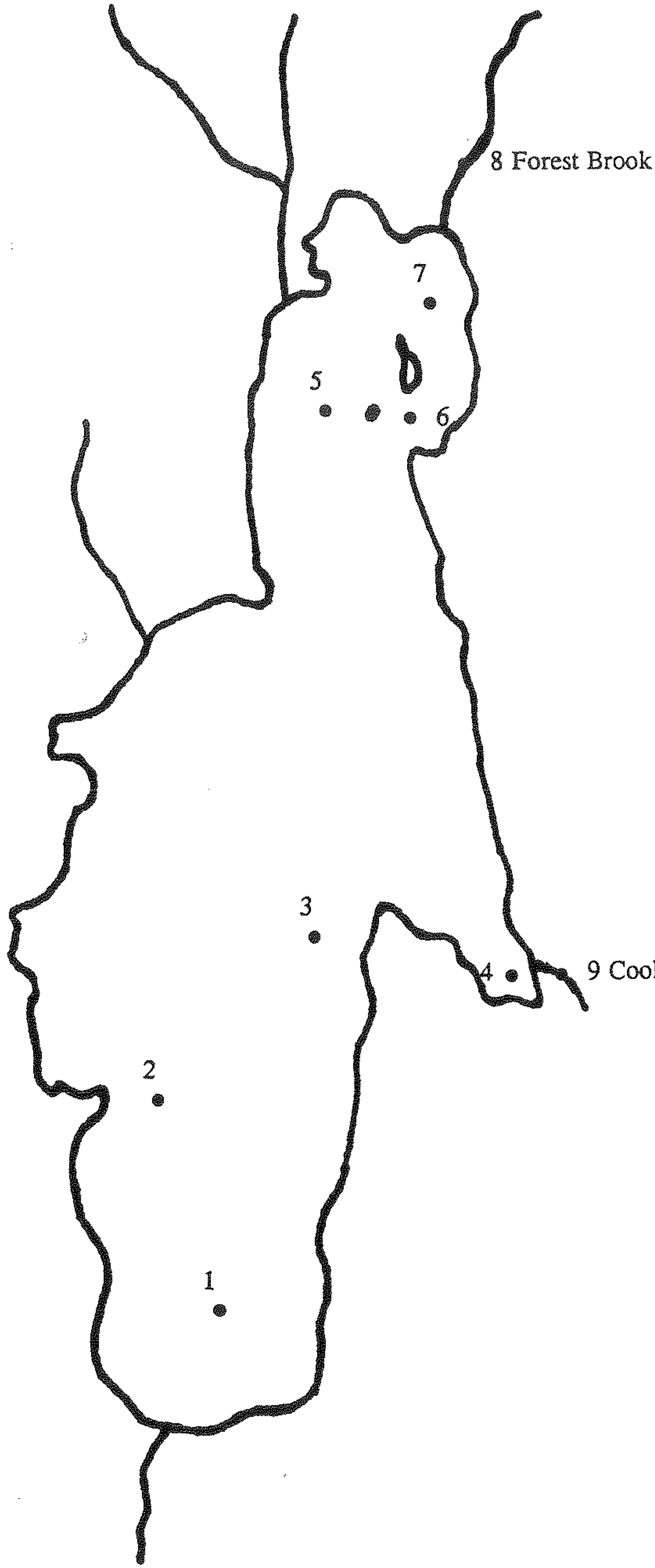
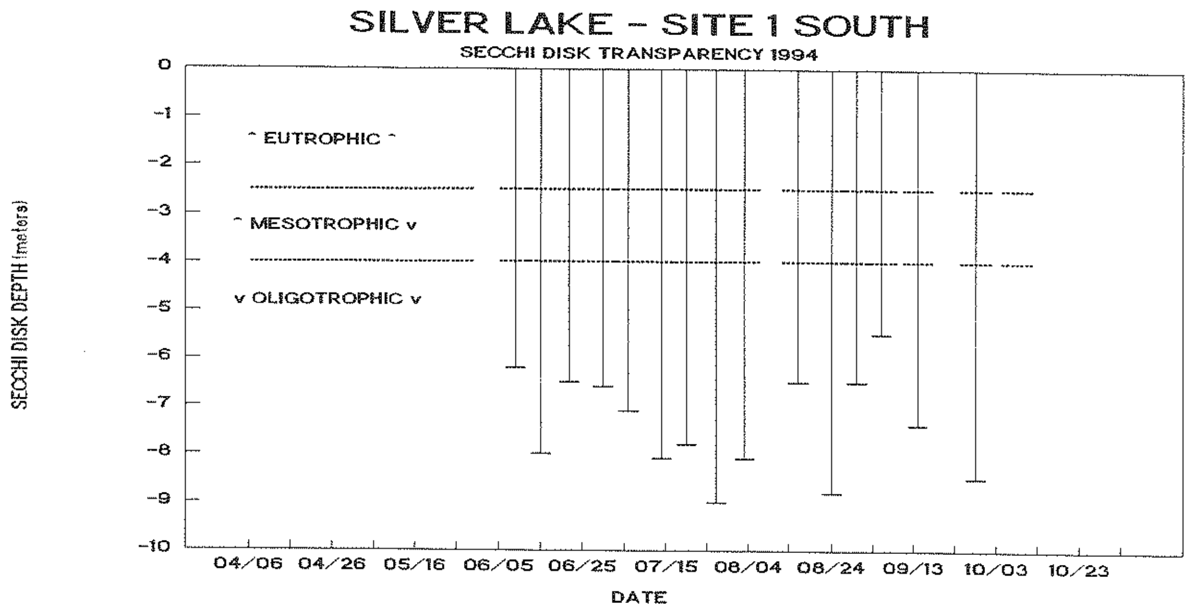
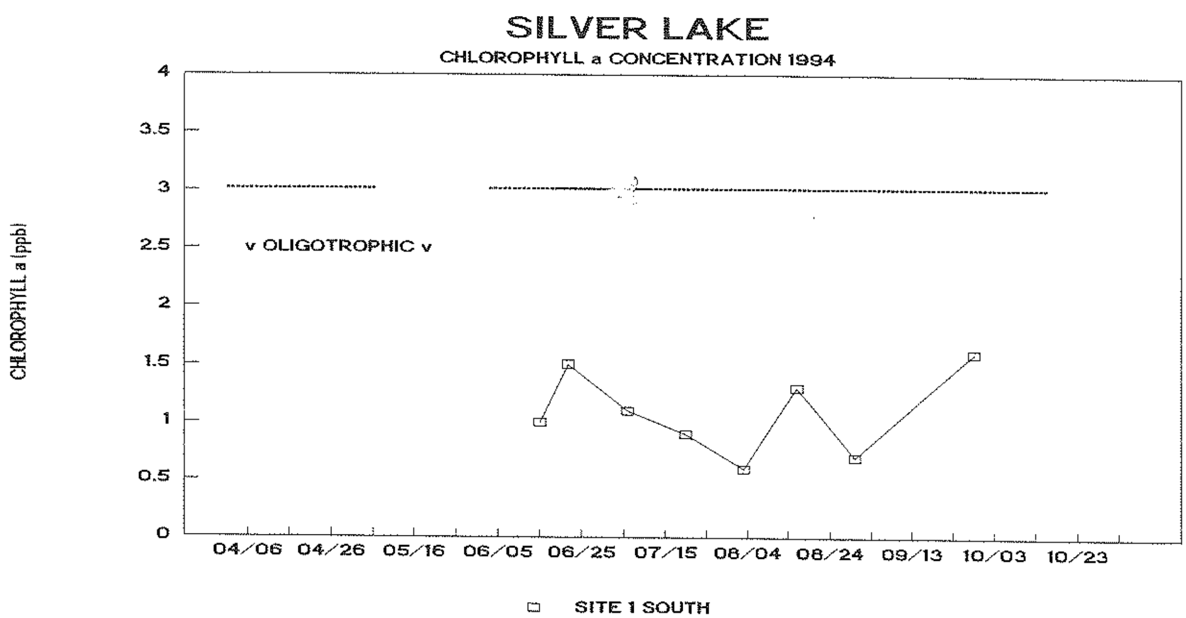

8 Forest Brook
7
5
6
3
4
9 Cooks Broo
2
1

Figure 6. Silver Lake, 1994. Seasonal Secchi Disk (water transparency) trends for lay monitor Site 1 South. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 7. Silver Lake, 1994. Seasonal chlorophyll *a* trends for lay monitor Site 1 South. Chlorophyll *a* concentrations are expressed as parts per billion (ppb) chlorophyll *a*. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 8. Silver Lake, 1994. Seasonal dissolved color trends for lay monitor Site 1 South. Dissolved color is expressed as platinum-cobalt units (ptu). The dotted horizontal line represents the dissolved color average for participating **LLMP** lakes.


SILVER LAKE - SITE 1 SOUTH
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SILVER LAKE
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 1 SOUTH

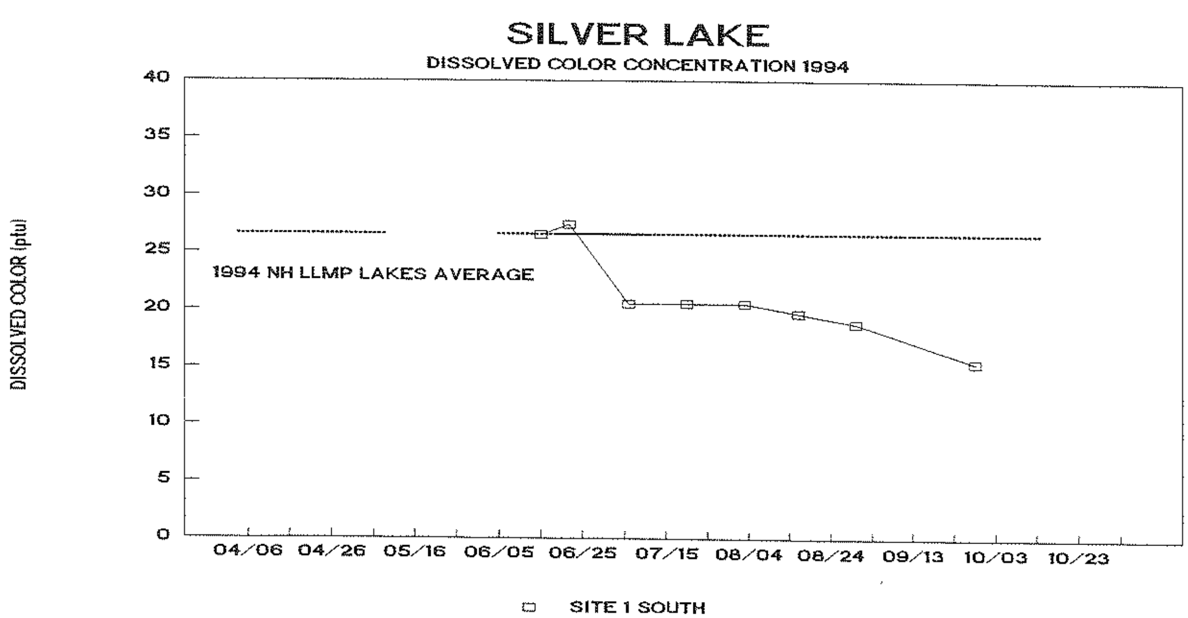

SILVER LAKE
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
40
35
30
25
20
15
10
5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 1 SOUTH

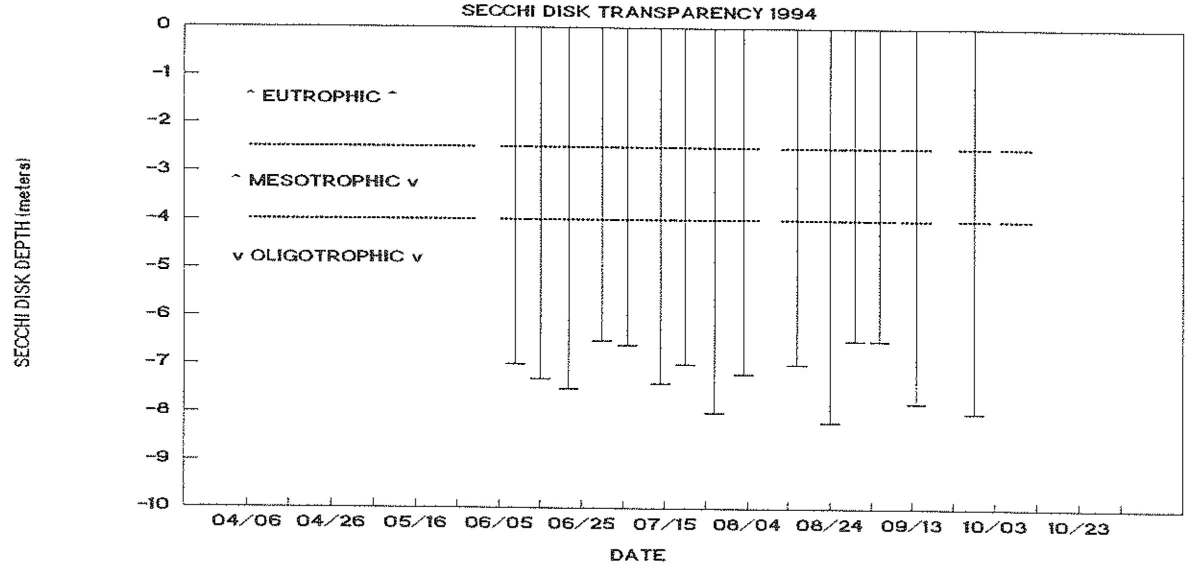
Figure 9. Silver Lake, 1994. Seasonal Secchi Disk (water transparency) trends for lay monitor Site 2 Deep. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 10. Silver Lake, 1994. Seasonal chlorophyll *a* trends for lay monitor Site 2 Deep. Chlorophyll *a* concentrations are expressed as parts per billion (ppb) chlorophyll *a*. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 11. Silver Lake, 1994. Seasonal dissolved color trends for lay monitor Site 2 Deep. Dissolved color is expressed as platinum-cobalt units (ptu). The dotted horizontal line represents the dissolved color average for participating **LLMP** lakes.

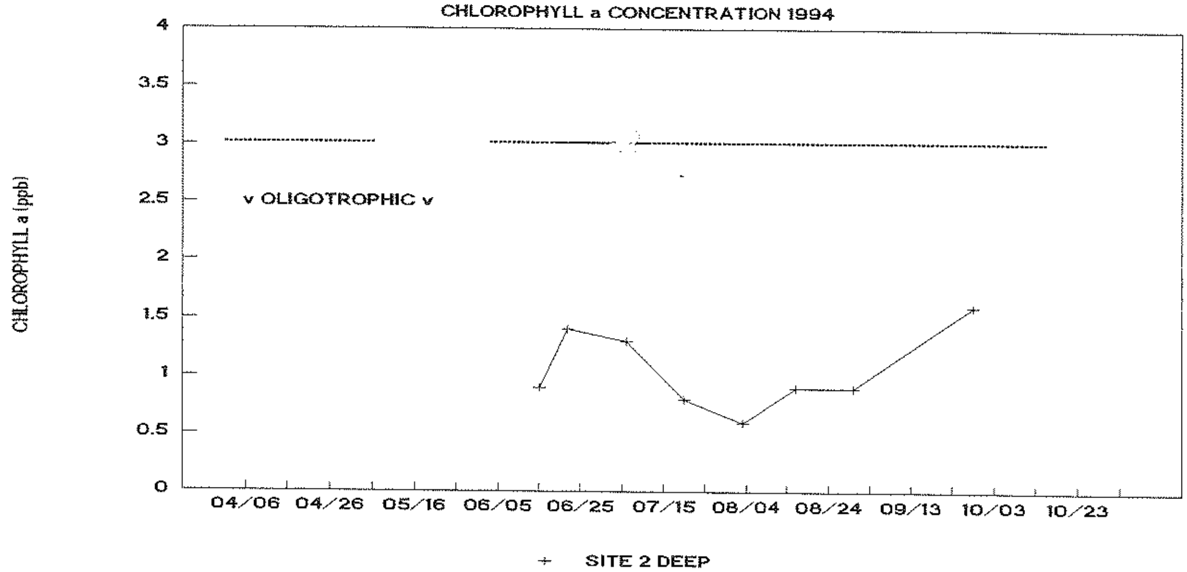
SILVER LAKE - SITE 2 DEEP

SECCHI DISK TRANSPARENCY 1994



SILVER LAKE

CHLOROPHYLL a CONCENTRATION 1994



SILVER LAKE

DISSOLVED COLOR CONCENTRATION 1994

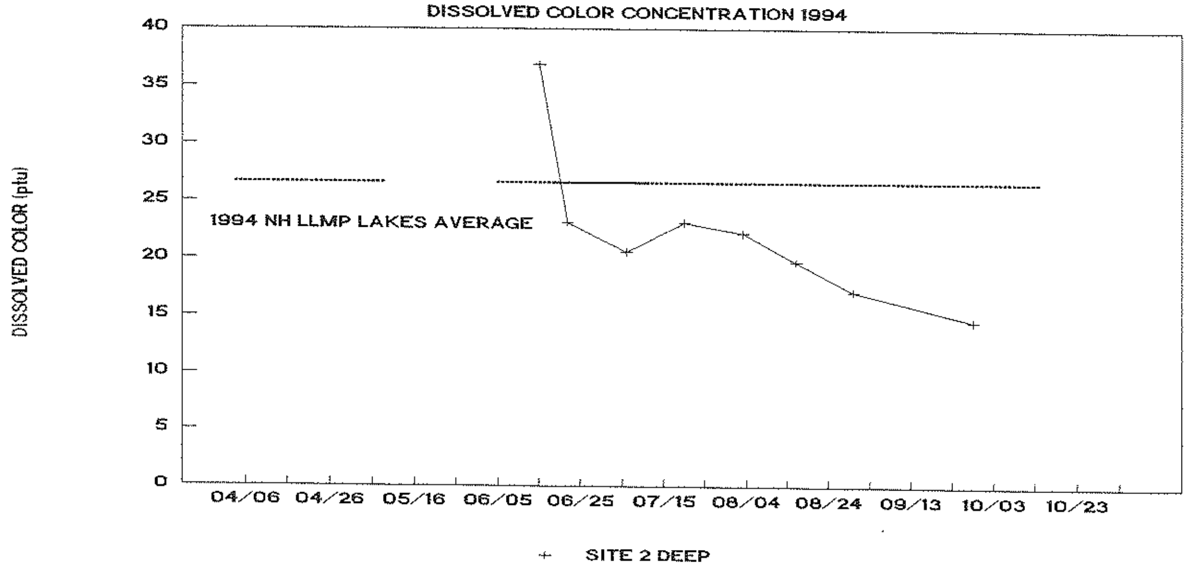
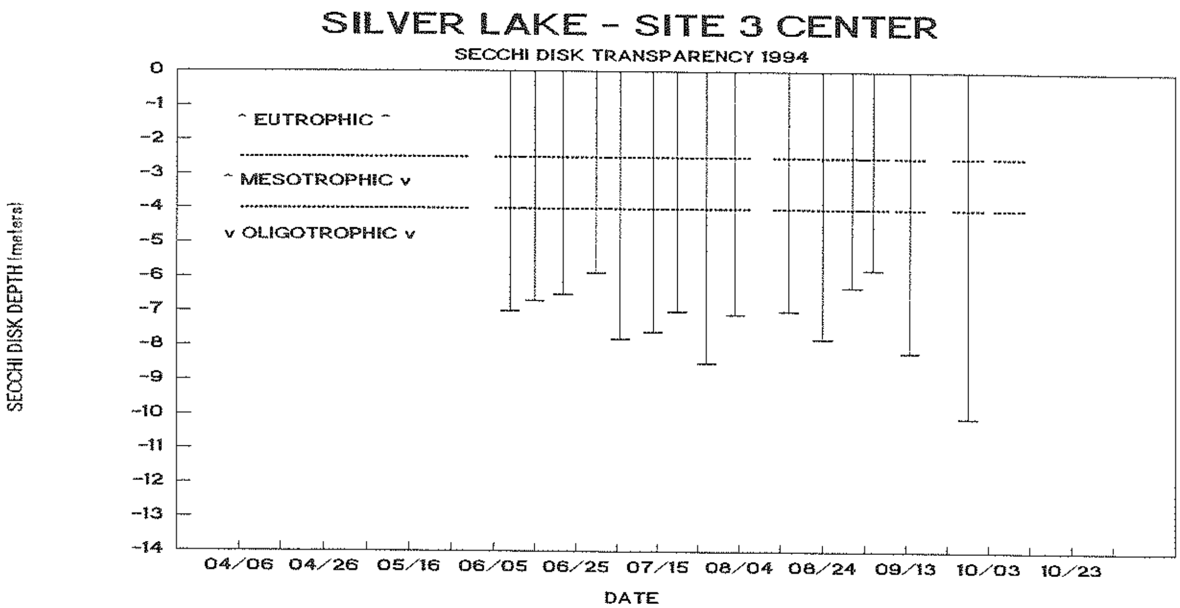
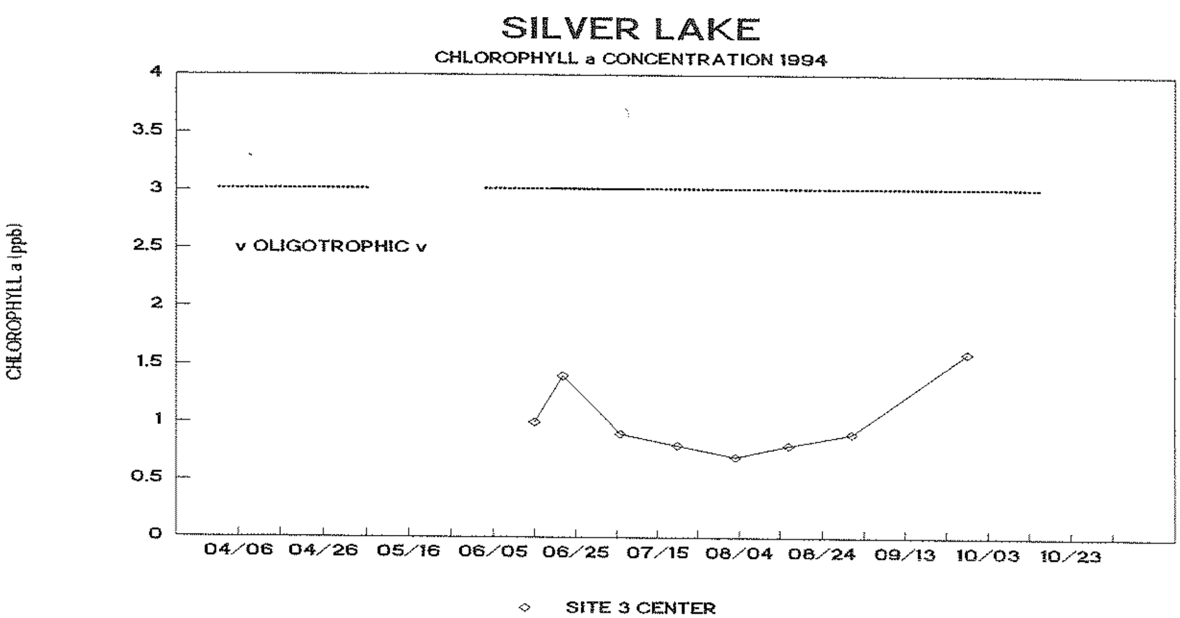


Figure 12. Silver Lake, 1994. Seasonal Secchi Disk (water transparency) trends for lay monitor Site 3 Center. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 13. Silver Lake, 1994. Seasonal chlorophyll *a* trends for lay monitor Site 3 Center. Chlorophyll *a* concentrations are expressed as parts per billion (ppb) chlorophyll *a*. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 14. Silver Lake, 1994. Seasonal dissolved color trends for lay monitor Site 3 Center. Dissolved color is expressed as platinum-cobalt units (ptu). The dotted horizontal line represents the dissolved color average for participating **LLMP** lakes.


SILVER LAKE - SITE 3 CENTER
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SILVER LAKE
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 3 CENTER

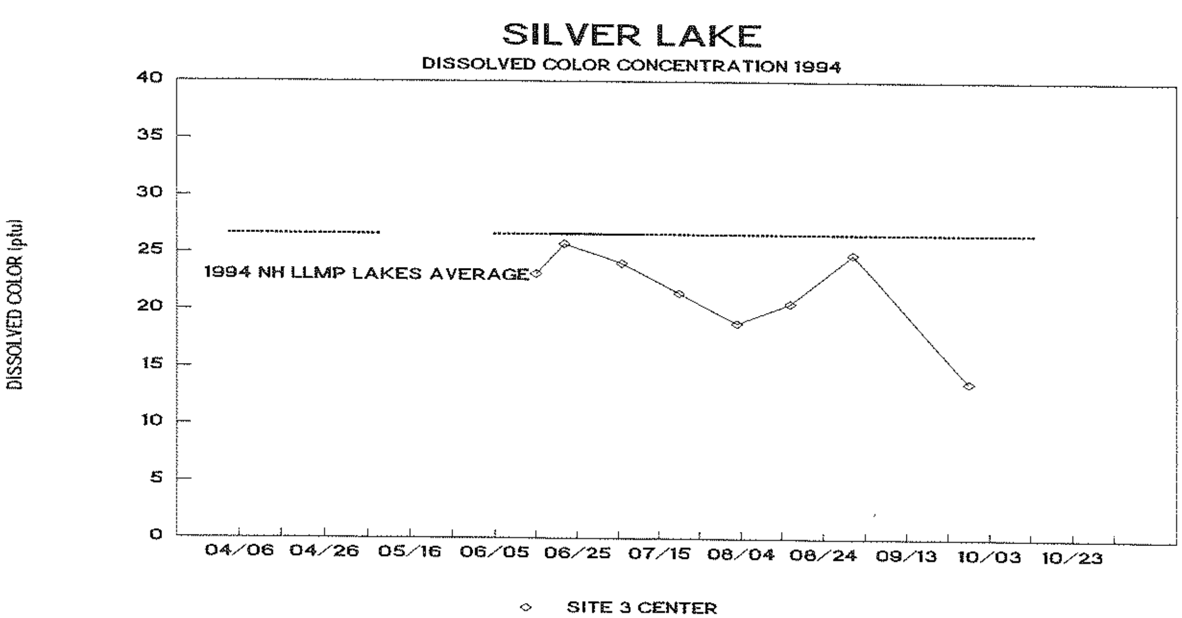
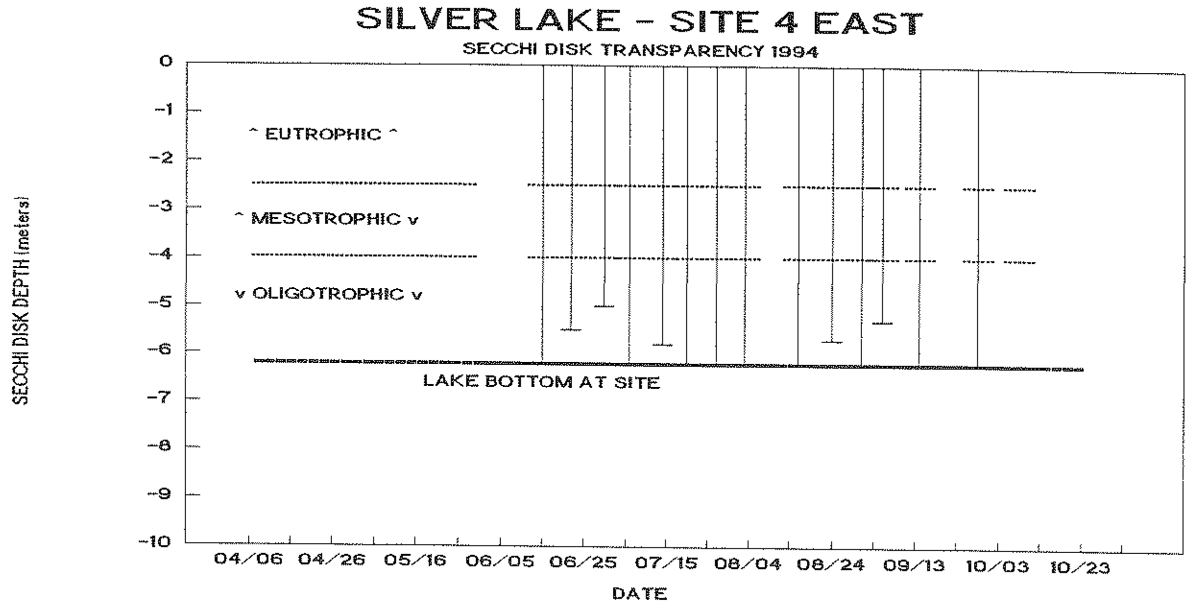
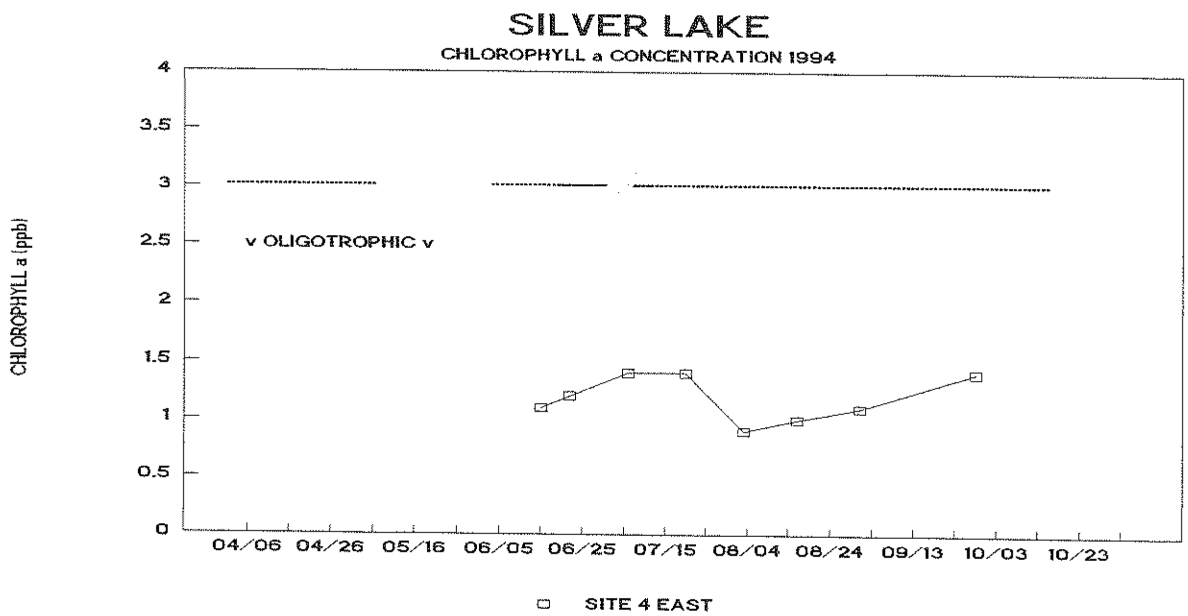

SILVER LAKE
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
40
35
30
25
20
15
10
5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 3 CENTER

Figure 15. Silver Lake, 1994. Seasonal Secchi Disk (water transparency) trends for lay monitor Site 4 East. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 16. Silver Lake, 1994. Seasonal chlorophyll *a* trends for lay monitor Site 4 East. Chlorophyll *a* concentrations are expressed as parts per billion (ppb) chlorophyll *a*. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 17. Silver Lake, 1994. Seasonal dissolved color trends for lay monitor Site 4 East. Dissolved color is expressed as platinum-cobalt units (ptu). The dotted horizontal line represents the dissolved color average for participating **LLMP** lakes.


SILVER LAKE - SITE 4 EAST
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SILVER LAKE
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 4 EAST

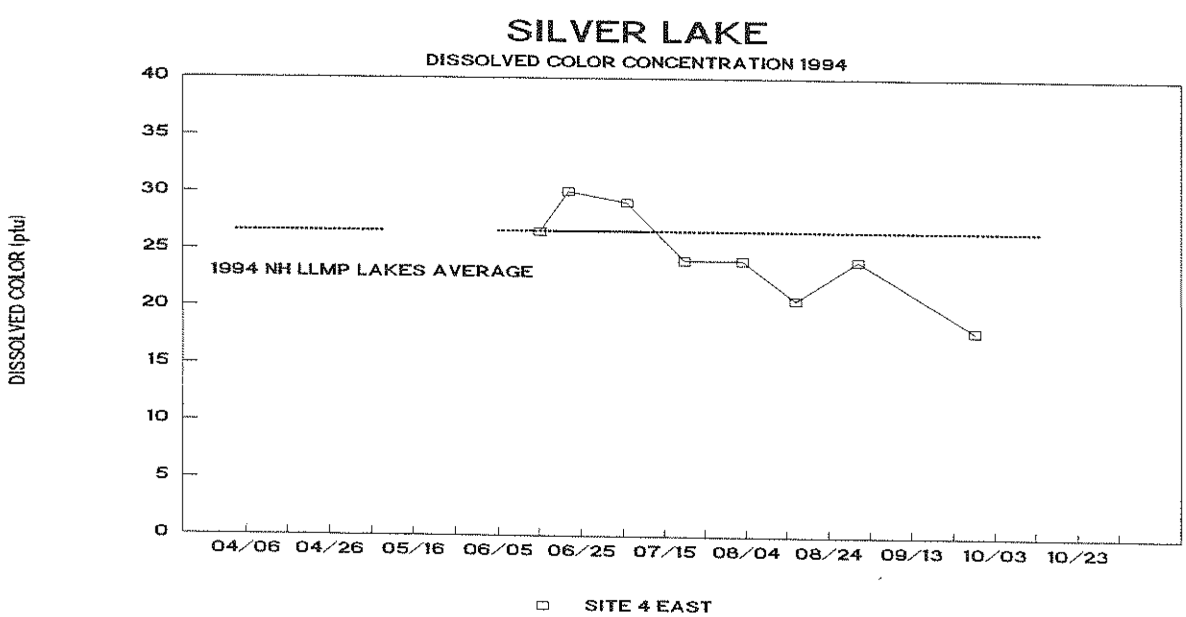
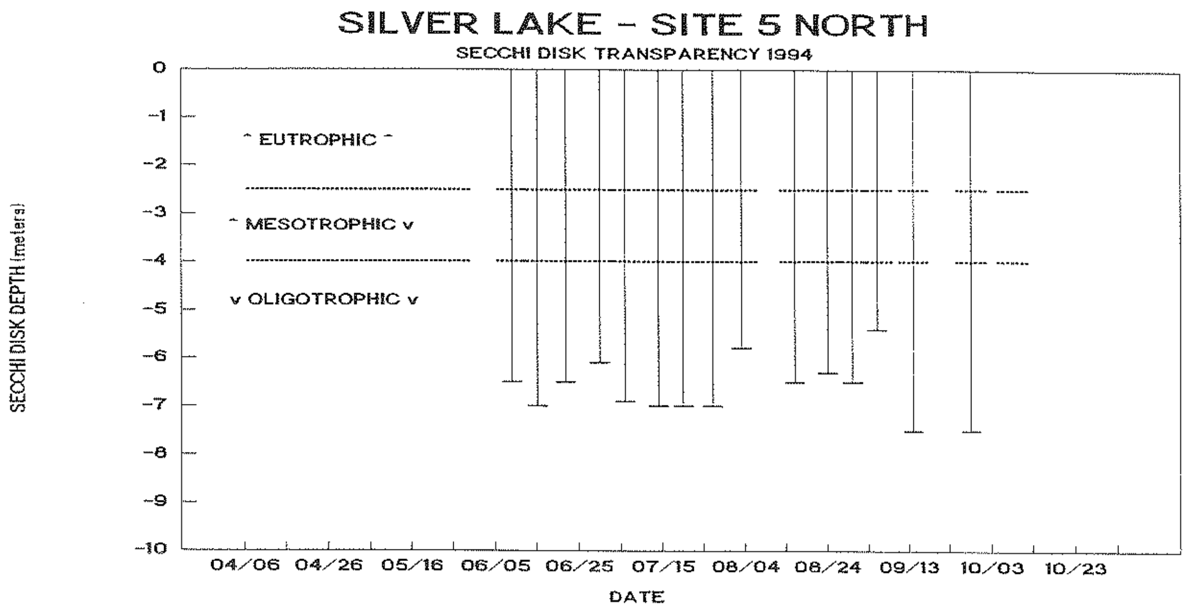
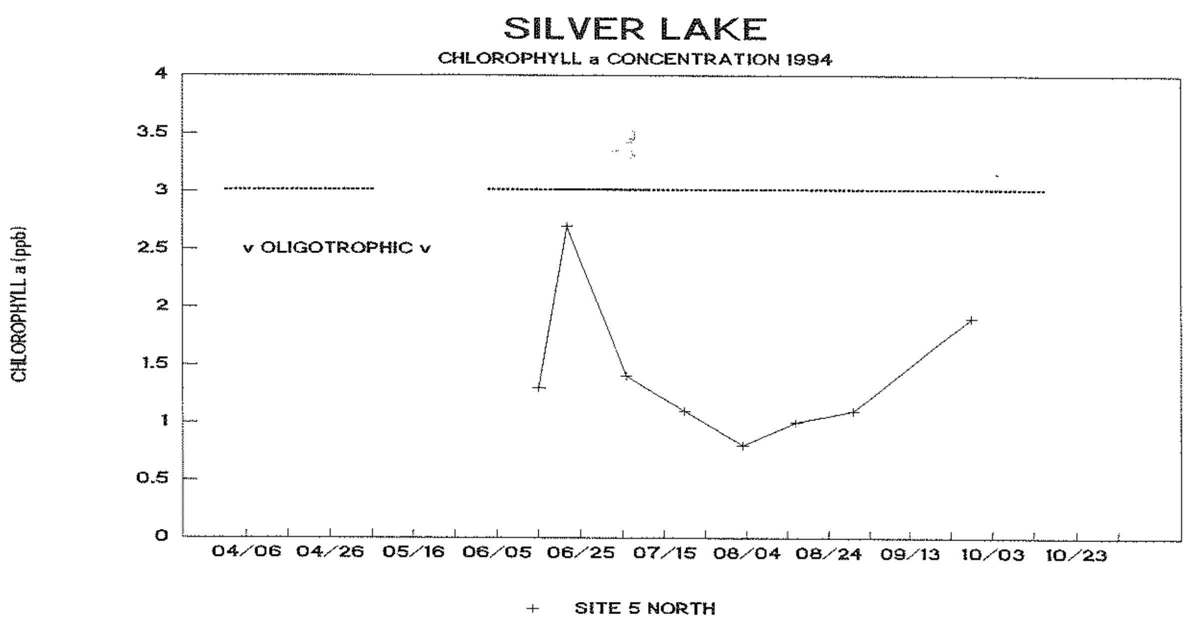

SILVER LAKE
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
40
35
30
25
20
15
10
5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 4 EAST

Figure 18. Silver Lake, 1994. Seasonal Secchi Disk (water transparency) trends for lay monitor Site 5 North. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 19. Silver Lake, 1994. Seasonal chlorophyll *a* trends for lay monitor Site 5 North. Chlorophyll *a* concentrations are expressed as parts per billion (ppb) chlorophyll *a*. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 20. Silver Lake, 1994. Seasonal dissolved color trends for lay monitor Site 5 North. Dissolved color is expressed as platinum-cobalt units (ptu). The dotted horizontal line represents the dissolved color average for participating **LLMP** lakes.


SILVER LAKE - SITE 5 NORTH
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SILVER LAKE
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
+ SITE 5 NORTH

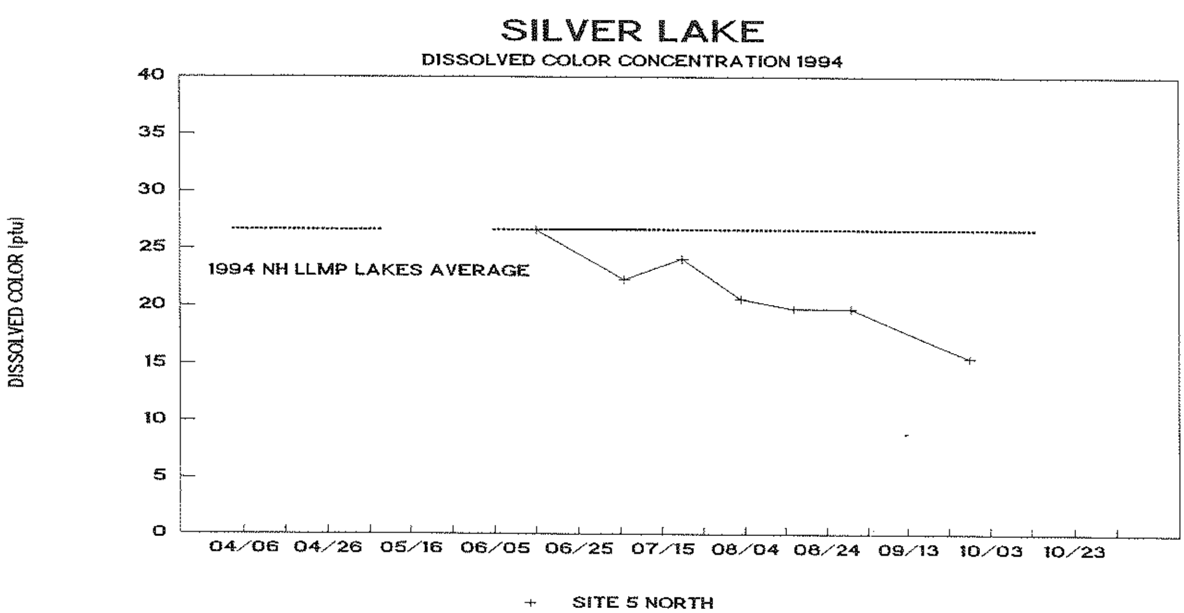
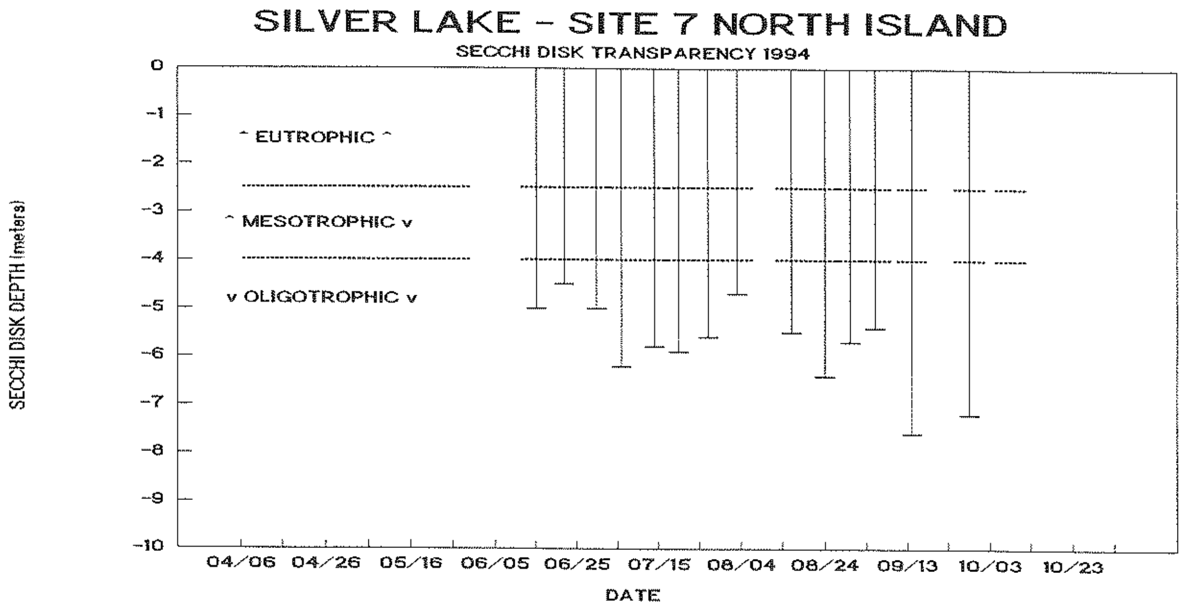
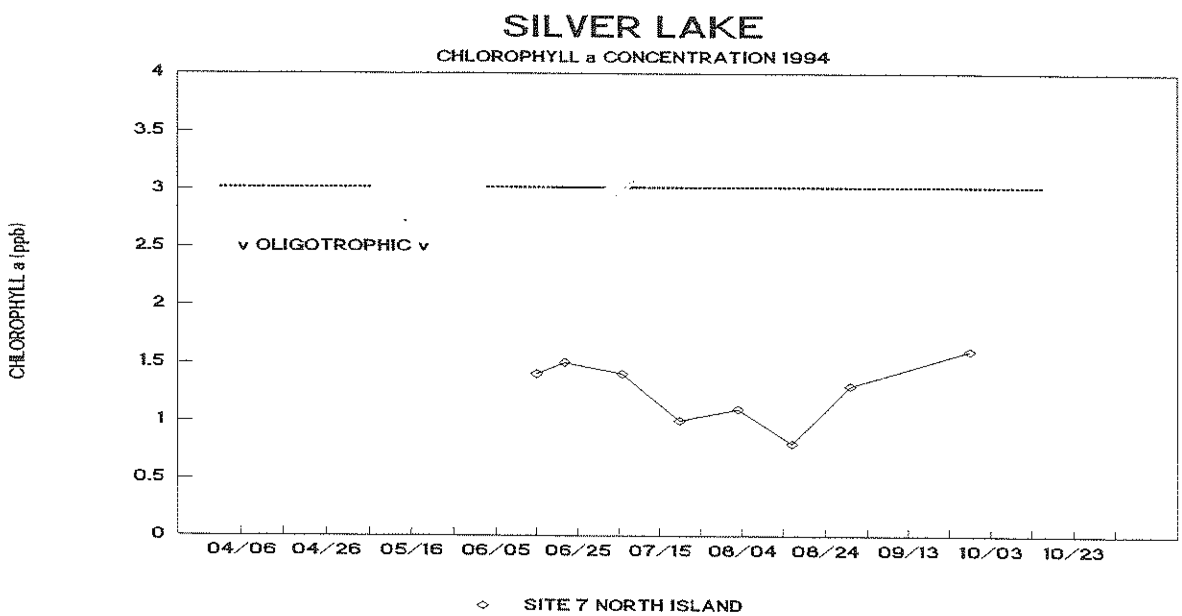

SILVER LAKE
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
40
35
30
25
20
15
10
5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
+ SITE 5 NORTH

Figure 21. Silver Lake, 1994. Seasonal Secchi Disk (water transparency) trends for lay monitor Site 7 North Island. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 22. Silver Lake, 1994. Seasonal chlorophyll *a* trends for lay monitor Site 7 North Island. Chlorophyll *a* concentrations are expressed as parts per billion (ppb) chlorophyll *a*. The dotted horizontal lines on the plot border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 23. Silver Lake, 1994. Seasonal dissolved color trends for lay monitor Site 7 North Island. Dissolved color is expressed as platinum-cobalt units (ptu). The dotted horizontal line represents the dissolved color average for participating **LLMP** lakes.


SILVER LAKE - SITE 7 NORTH ISLAND
SECCHI DISK TRANSPARENCY 1994
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SILVER LAKE
CHLOROPHYLL a CONCENTRATION 1994
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 7 NORTH ISLAND

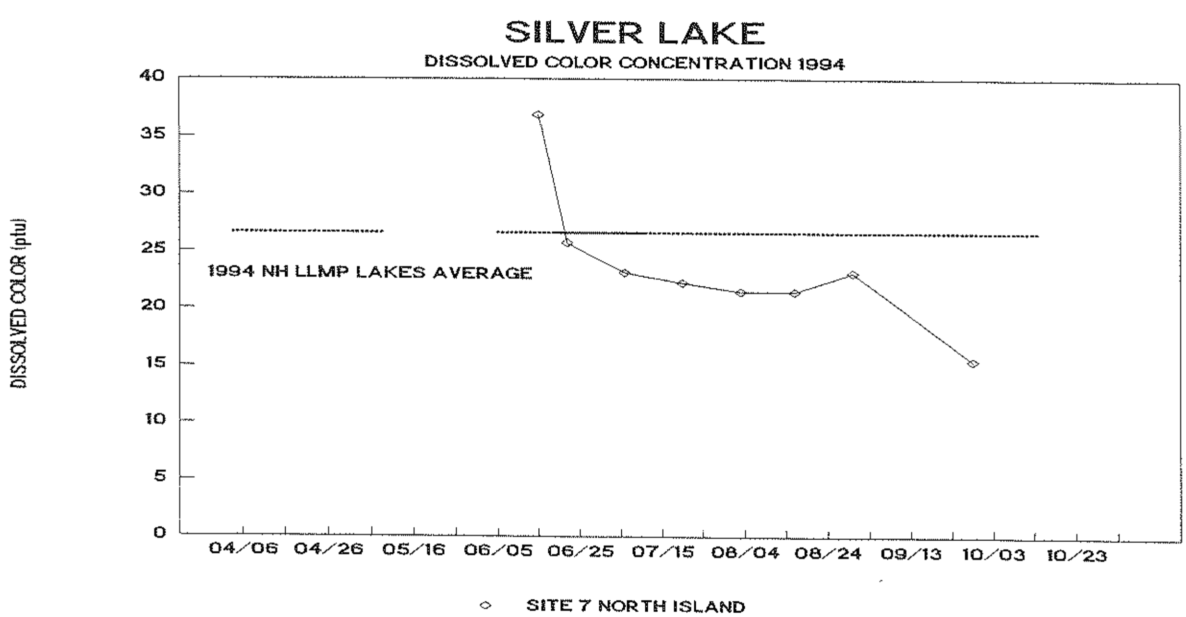
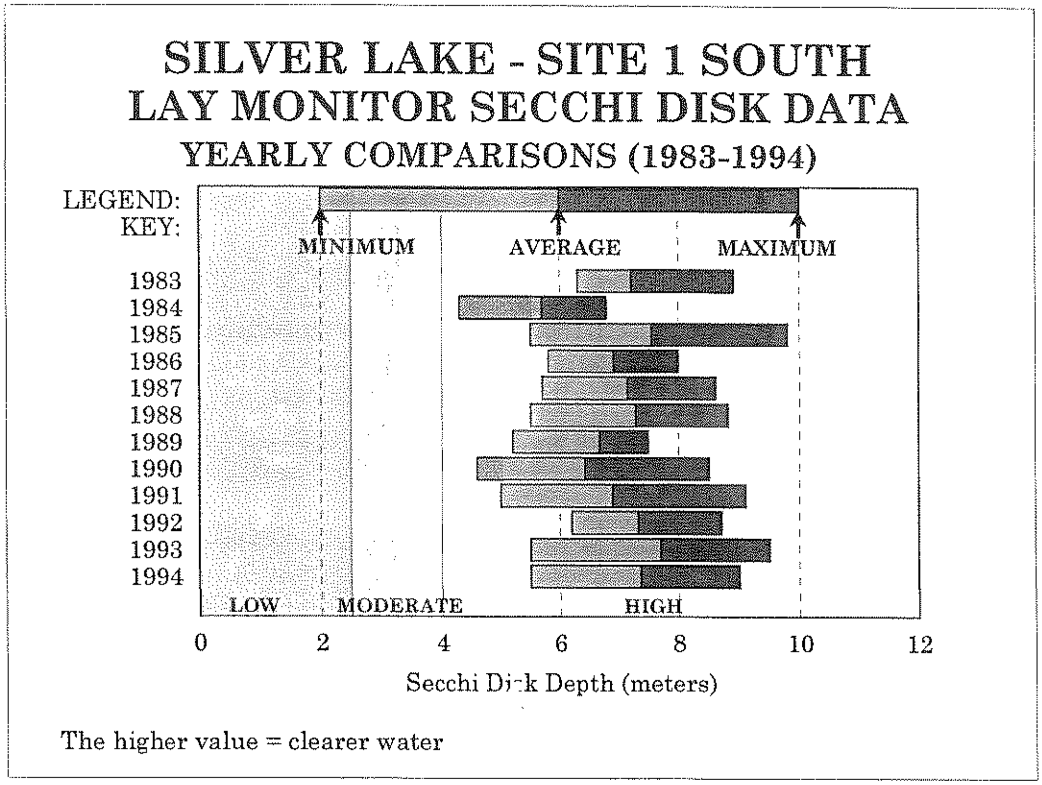
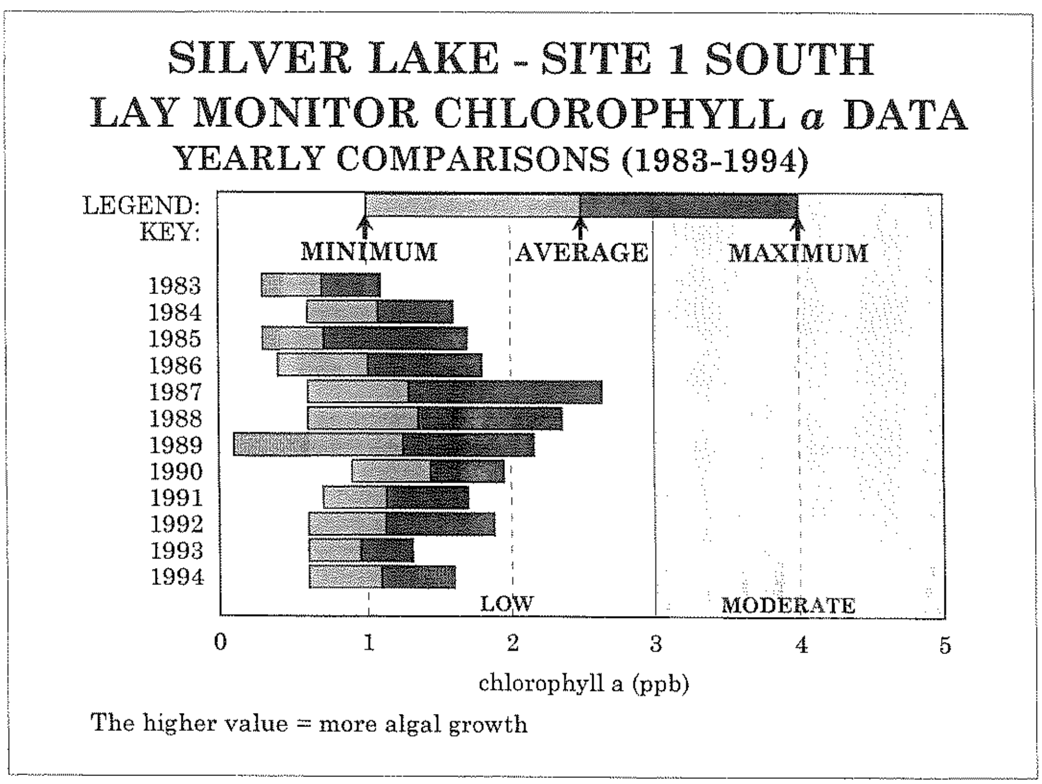

SILVER LAKE
DISSOLVED COLOR CONCENTRATION 1994
DISSOLVED COLOR (ptu)
1994 NH LLMP LAKES AVERAGE
40
35
30
25
20
15
10
5
0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE 7 NORTH ISLAND

Figure 24. Comparison of the 1994 Silver Lake, Site 1 South, lay monitor Secchi Disk transparency data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk value the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 25. Comparison of the 1994 Silver Lake, Site 1 South, lay monitor chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).



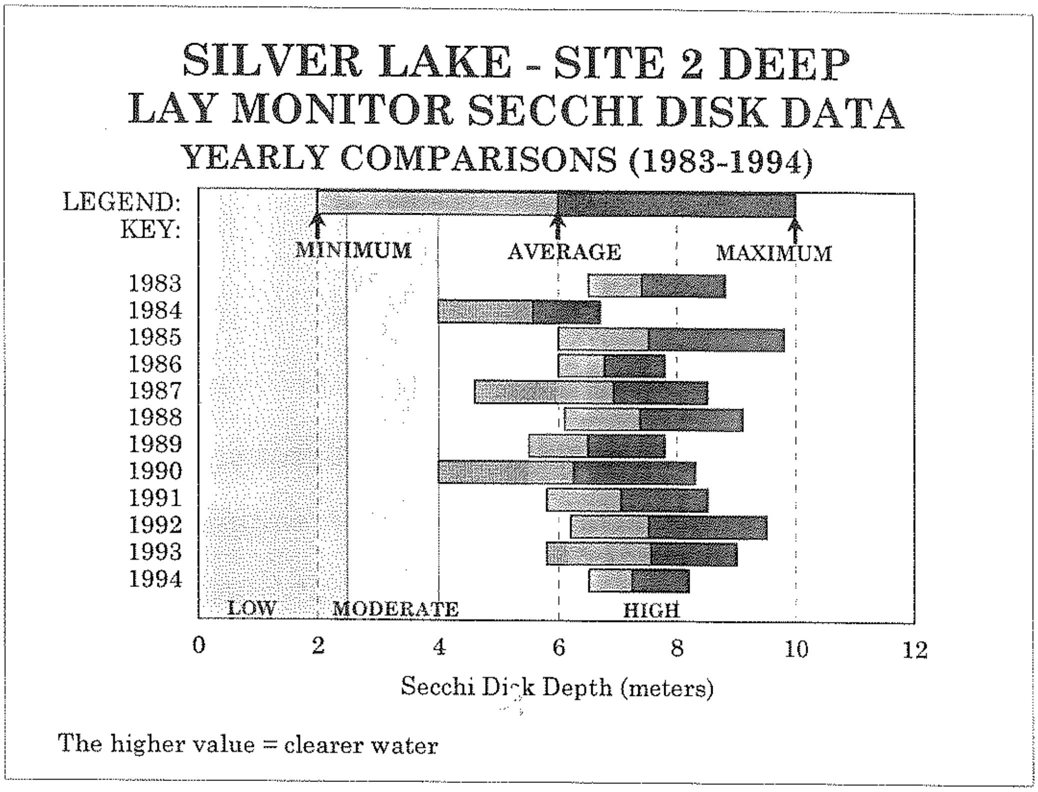
SILVER LAKE - SITE 1 SOUTH
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
Secchi Disk Depth (meters)
The higher value = clearer water



SILVER LAKE - SITE 1 SOUTH
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
0
1
2
3
4
5
chlorophyll a (ppb)
The higher value = more algal growth

Figure 26. Comparison of the 1994 Silver Lake, Site 2 Deep, lay monitor Secchi Disk transparency data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk value the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 27. Comparison of the 1994 Silver Lake, Site 2 Deep, lay monitor chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


SILVER LAKE - SITE 2 DEEP
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
Secchi Disk Depth (meters)
The higher value = clearer water

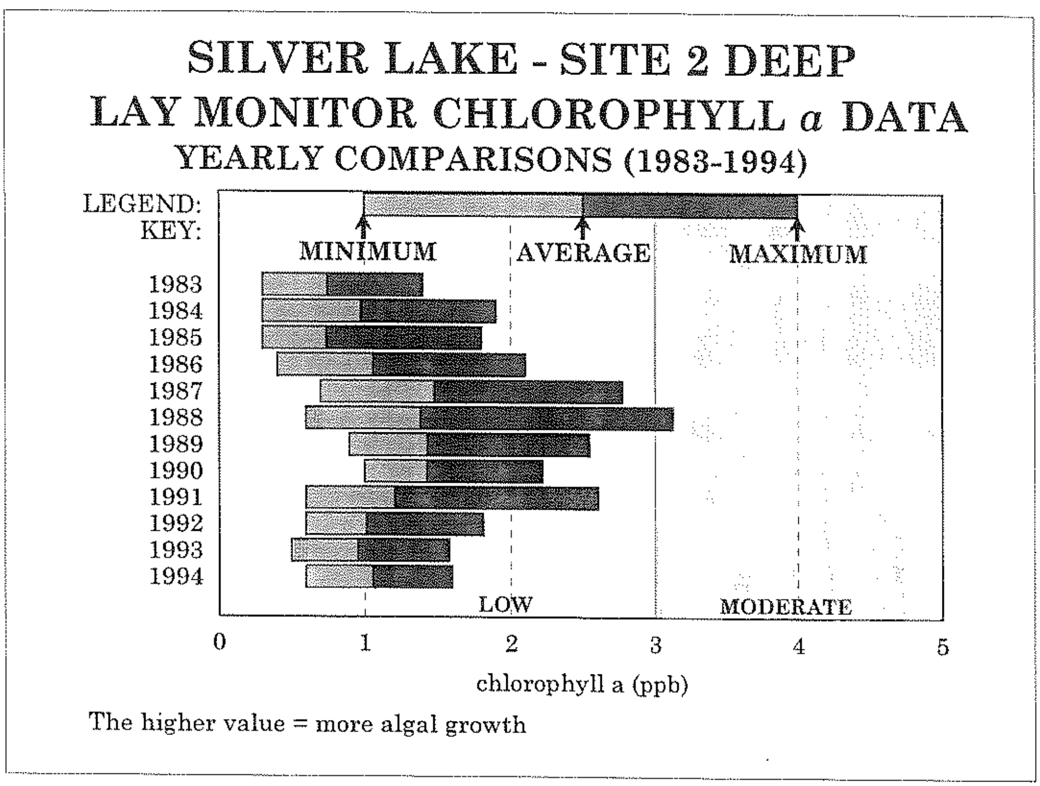
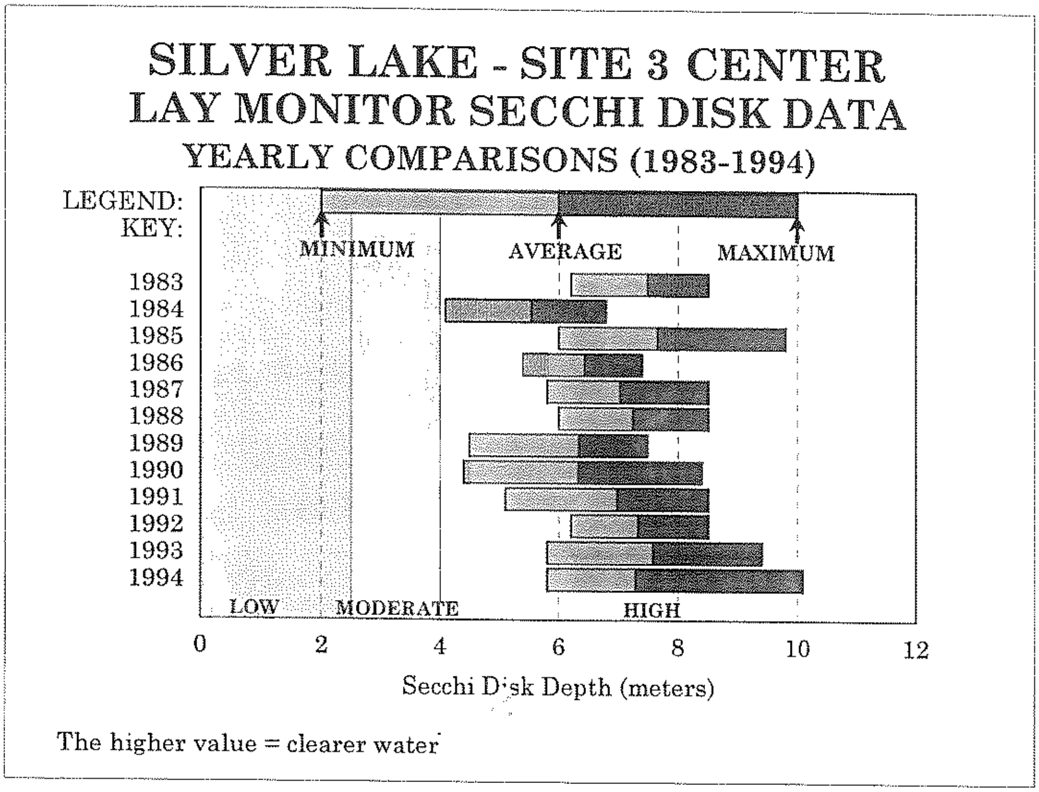

SILVER LAKE - SITE 2 DEEP
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
0
1
2
3
4
5
chlorophyll a (ppb)
The higher value = more algal growth

Figure 28. Comparison of the 1994 Silver Lake, Site 3 Center, lay monitor Secchi Disk transparency data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk value the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 29. Comparison of the 1994 Silver Lake, Site 3 Center, lay monitor chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


SILVER LAKE - SITE 3 CENTER
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
Secchi Disk Depth (meters)
The higher value = clearer water

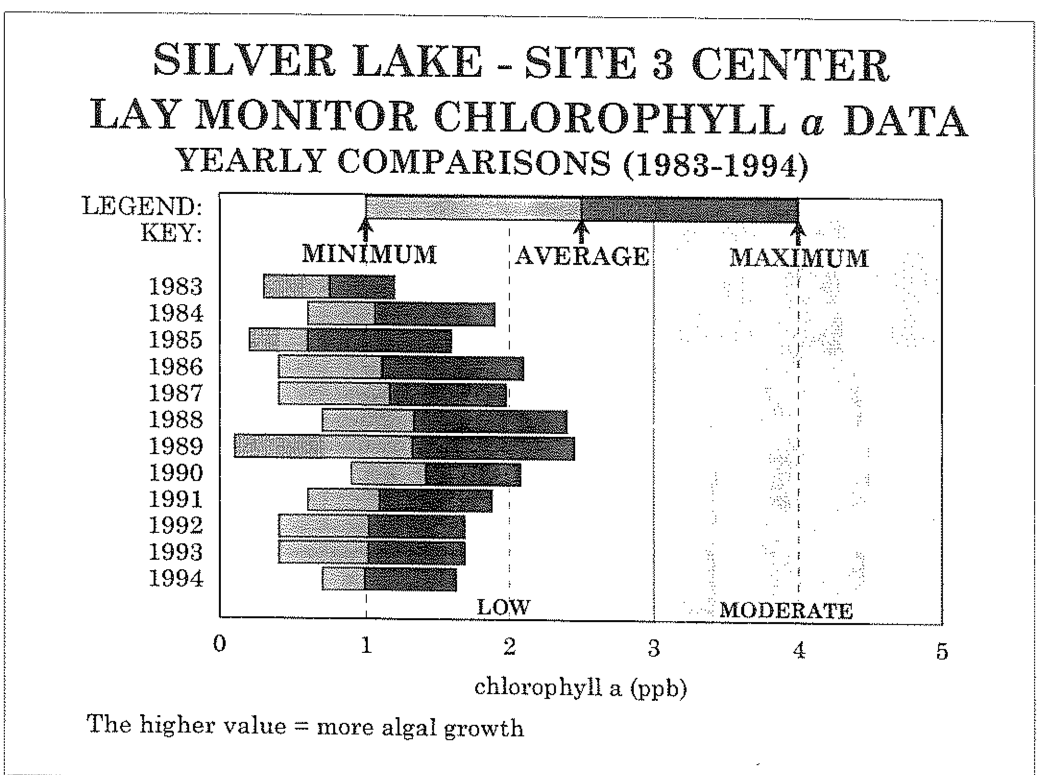
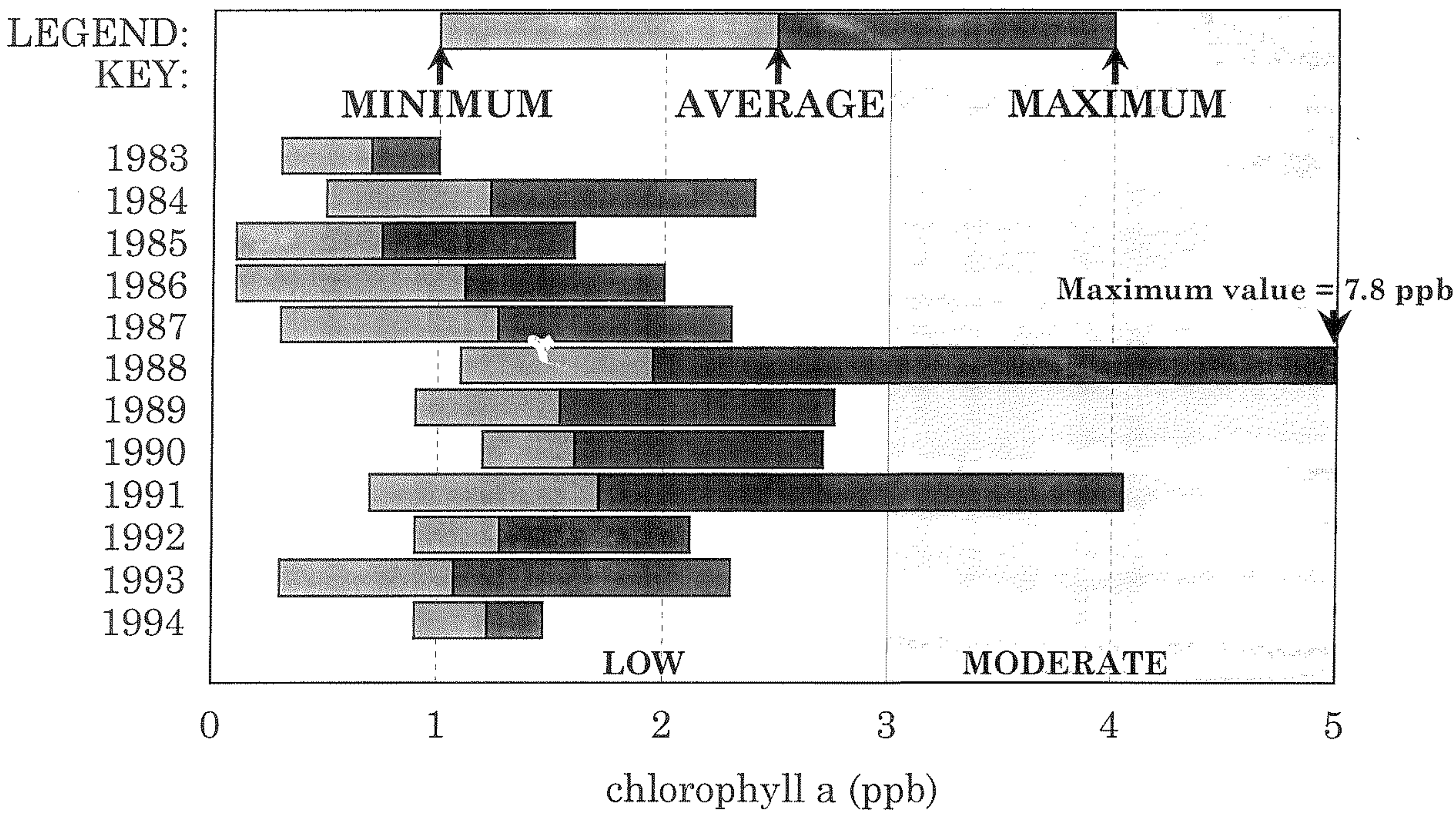

SILVER LAKE - SITE 3 CENTER
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
0
1
2
3
4
5
chlorophyll a (ppb)
The higher value = more algal growth

Figure 30. Comparison of the 1994 Silver Lake, Site 4 East, lay monitor chlorophyll a data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high chlorophyll a concentrations. The higher the chlorophyll a concentration the greener the water (i.e. more algal growth).

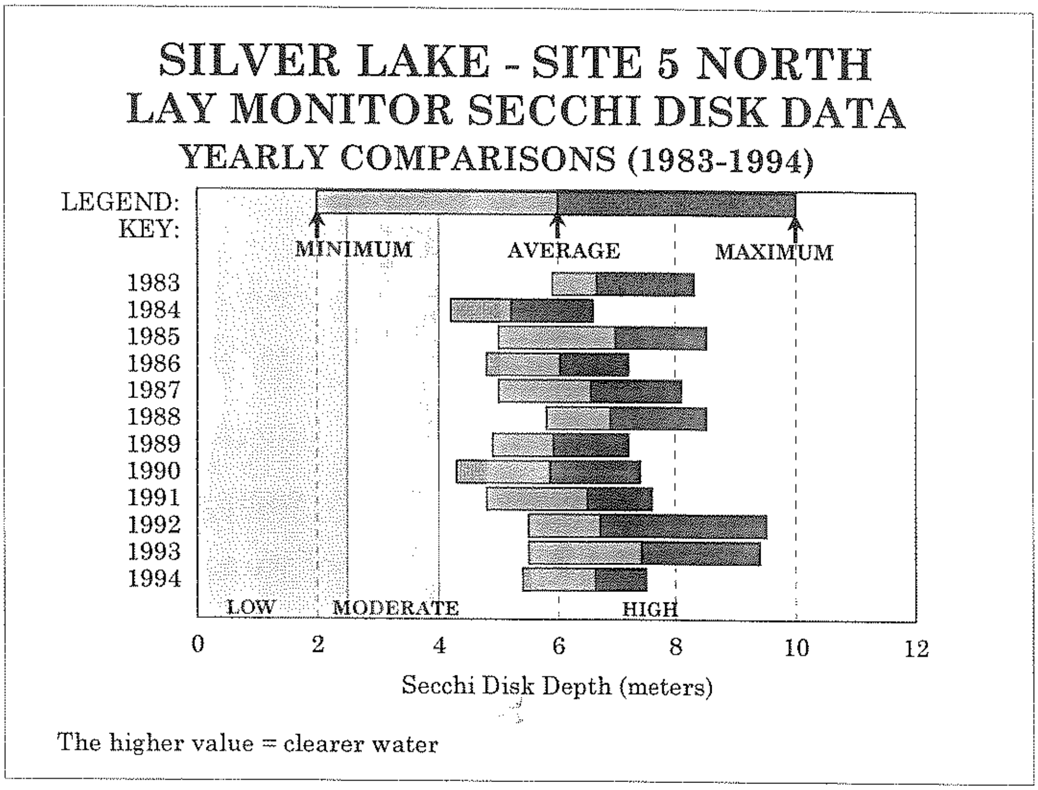
SILVER LAKE - SITE 4 EAST
LAY MONITOR CHLOROPHYLL *a* DATA
YEARLY COMPARISONS (1983-1994)



The higher value = more algal growth

Figure 31. Comparison of the 1994 Silver Lake, Site 5 North, lay monitor Secchi Disk transparency data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk value the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 32. Comparison of the 1994 Silver Lake, Site 5 North, lay monitor chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


SILVER LAKE - SITE 5 NORTH
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
Secchi Disk Depth (meters)
The higher value = clearer water

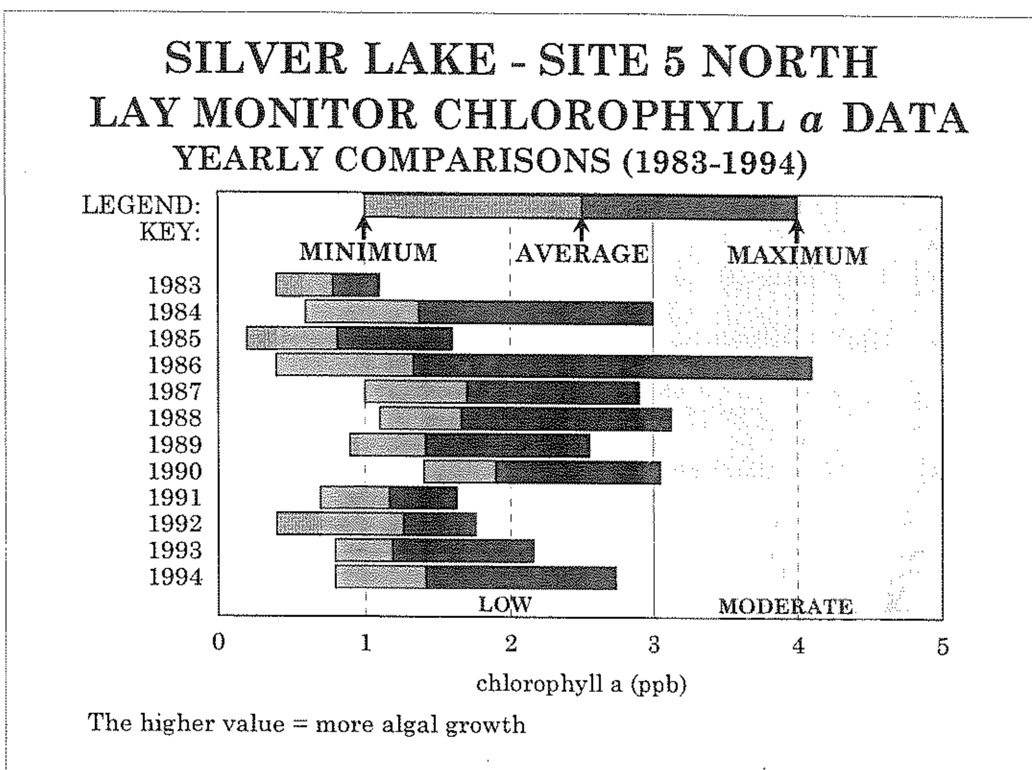
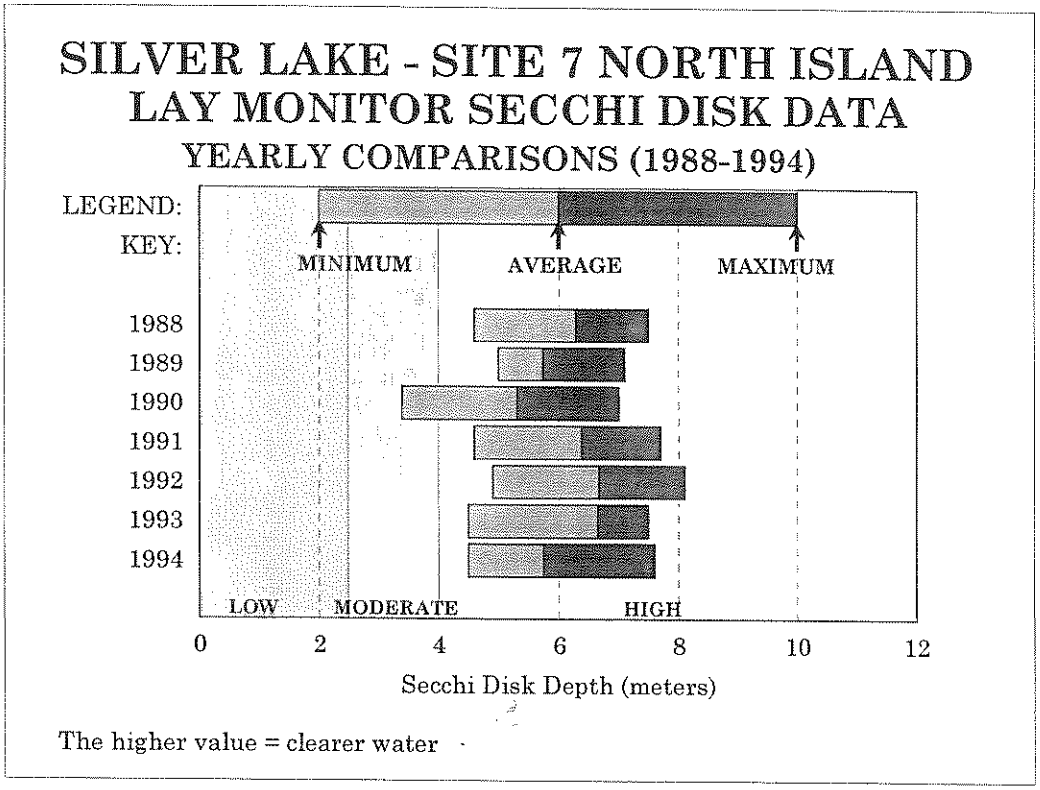

SILVER LAKE - SITE 5 NORTH
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1983-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
0
1
2
3
4
5
chlorophyll a (ppb)
The higher value = more algal growth

Figure 33. Comparison of the 1994 Silver Lake, Site 7 North Island, lay monitor Secchi Disk transparency data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk value the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 34. Comparison of the 1994 Silver Lake, Site 7 North Island, lay monitor chlorophyll *a* data with previous yearly data. The patterns of the bars display the minimum, average and maximum values for the respective years sampled while the length of the bars represents the total range of values. The shaded regions on the graph denote the ranges characteristic of low, moderate and high chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


SILVER LAKE - SITE 7 NORTH ISLAND
LAY MONITOR SECCHI DISK DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
Secchi Disk Depth (meters)
The higher value = clearer water

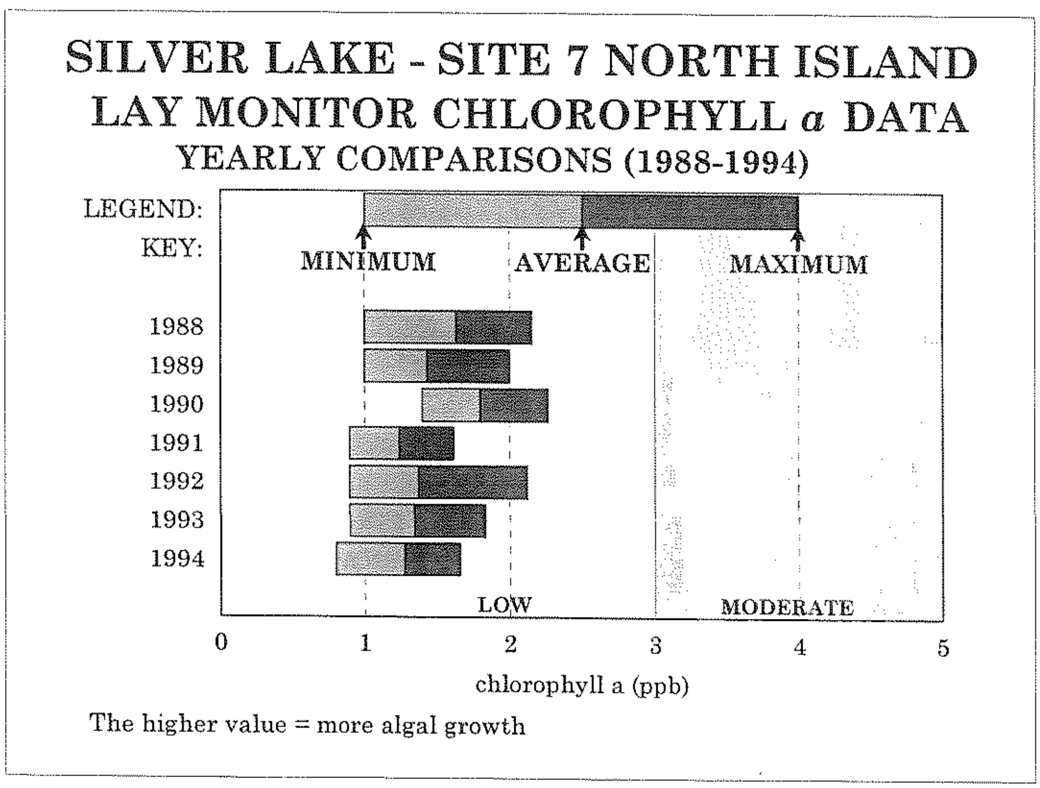
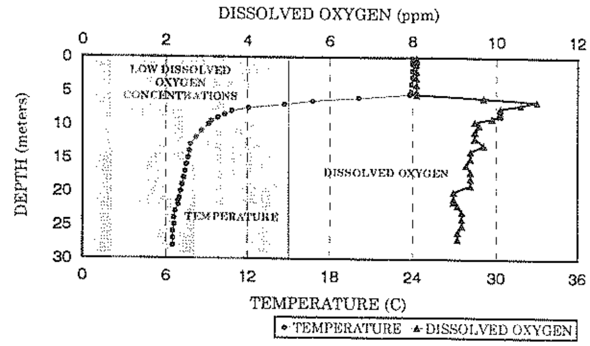
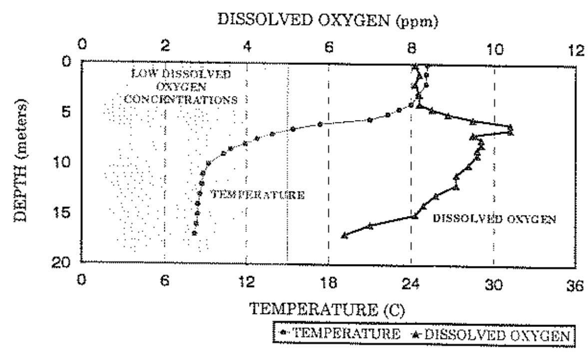

SILVER LAKE - SITE 7 NORTH ISLAND
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1988-1994)
LEGEND:
KEY:
MINIMUM
AVERAGE
MAXIMUM
1988
1989
1990
1991
1992
1993
1994
LOW
MODERATE
0
1
2
3
4
5
chlorophyll a (ppb)
The higher value = more algal growth

Figure 35. 1994 Silver Lake temperature and dissolved oxygen profiles collected on August 10, 1994 from the 2 Deep, 5 North and 7 North Island Sampling locations. The dissolved oxygen and temperature readings were measured at one-half meter intervals.

SILVER LAKE - SITE 2 DEEP
AUGUST 10, 1994



SILVER LAKE - SITE 5 NORTH
AUGUST 10, 1994



SILVER LAKE - SITE 7 NORTH ISLAND
AUGUST 10, 1994

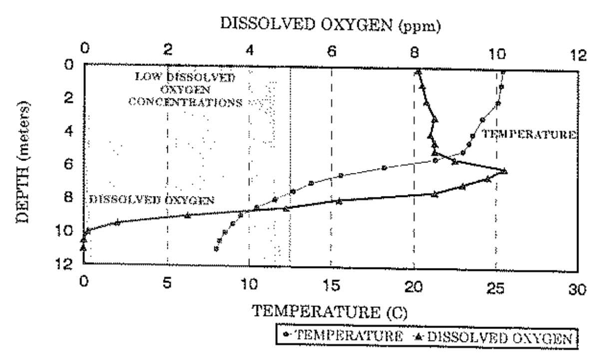


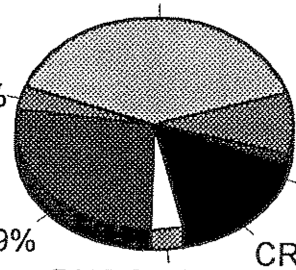
Figure 36. Pie diagrams of phytoplankton compostition collected at the Silver Lake deep sampling stations; 2 Deep, 5 North and 7 North Island, on August 10, 1994. The sample depths are as indicated above the respective pie diagrams. Phytoplankton densities are presented as percent abundance by algal class.

Silver Lake (Madison)

August 10, 1994

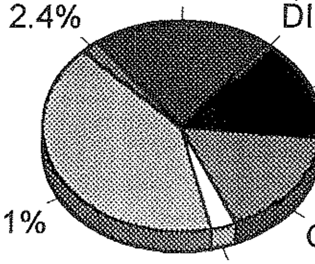
Site 2 Deep

Depth : 0 - 5.5 meters



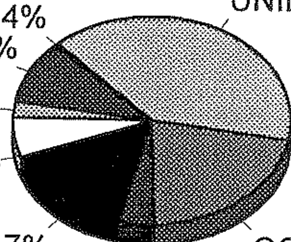
Site 5 North

Depth : 0 - 4.0 meters



Site 7 North Island

Depth : 0 - 5.0 meters

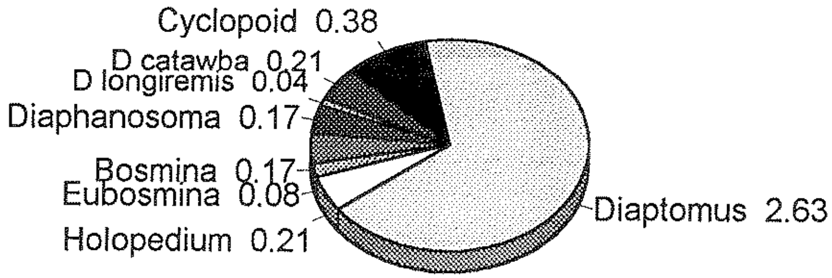


Phytoplankton densities are presented as % abundance by algal class.

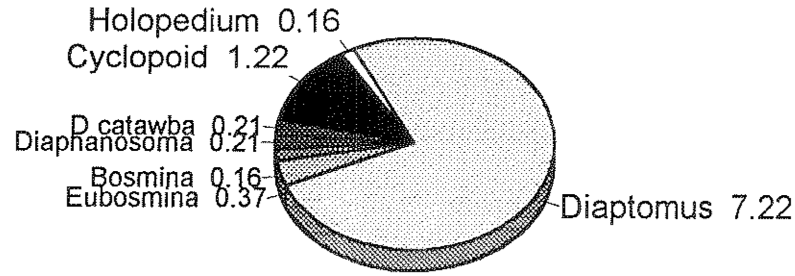
Figure 37. Pie diagrams of Macrozooplankton compostition collected at the Silver Lake deep sampling stations; 2 Deep, 5 North and 7 North Island, on August 10, 1994. The vertical sampling depths are as indicated above the respective pie diagrams. Macrozooplankton densities are presented as number of animals per liter.

Silver Lake (Madison)
August 10, 1994

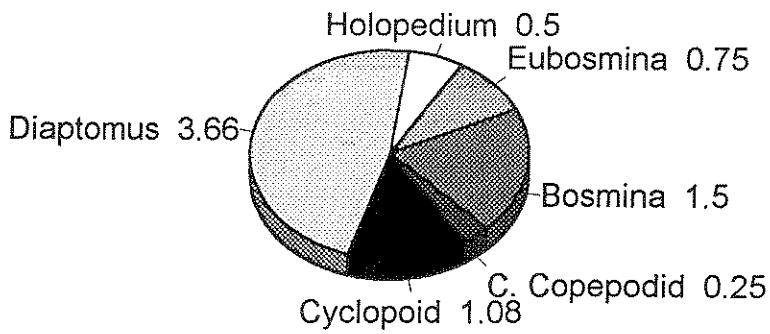
Site 2 Deep
Depth of Tow : 0 - 20.0 meters



Site 5 North
Depth of Tow : 0 - 16.0 meters



Site 7 North Island
Depth of Tow : 0 - 8.5 meters



Macrozooplankton densities are presented as # animals per liter.

APPENDIX A

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Silver Lake, Madison, NH
-- subset of trophic indicators, all sites, 1994

1994 SUMMARY

Average transparency:	6.8	(1994:	79	values;	4.5	-	10.1	range)
Average chlorophyll:	1.2	(1994:	48	values;	0.6	-	2.7	range)
Average Lake phos.:	4.7	(1994:	6	values;	3.1	-	5.8	range)
Average alk (gray):	3.0	(1994:	48	values;	2.5	-	3.3	range)
Average alk (pink):	3.5	(1994:	48	values;	3.1	-	4.2	range)
Average color, 440:	22.5	(1994:	47	values;	13.7	-	36.9	range)
Average Trib. phos:	5.9	(1994:	3	values;	4.6	-	7.9	range)

Site	Date	Trans-parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 South	06/09/1994	6.2	----	----	----	----	----
1 South	06/15/1994	8.0	1.0	----	3.3	3.7	26.6
1 South	06/22/1994	6.5	1.5	----	3.1	3.6	27.5
1 South	06/30/1994	6.6	----	----	----	----	----
1 South	07/06/1994	7.1	1.1	----	3.1	3.6	20.6
1 South	07/14/1994	8.1	----	----	----	----	----
1 South	07/20/1994	7.8	0.9	----	2.5	4.2	20.6
1 South	07/27/1994	9.0	----	----	----	----	----
1 South	08/03/1994	8.1	0.6	----	3.2	3.5	20.6
1 South	08/16/1994	6.5	1.3	----	3.2	3.5	19.8
1 South	08/24/1994	8.8	----	----	----	----	----
1 South	08/30/1994	6.5	0.7	----	3.0	3.2	18.9
1 South	09/05/1994	5.5	----	----	----	----	----
1 South	09/14/1994	7.4	----	5.3	----	----	----
1 South	09/28/1994	8.5	1.6	----	3.1	3.6	15.5
2 Deep	06/09/1994	7.0	----	----	----	----	----
2 Deep	06/15/1994	7.3	0.9	----	3.1	3.7	36.9
2 Deep	06/22/1994	7.5	1.4	----	3.0	3.4	23.2
2 Deep	06/30/1994	6.5	----	----	----	----	----
2 Deep	07/06/1994	6.6	1.3	----	3.0	3.5	20.6
2 Deep	07/14/1994	7.4	----	----	----	----	----
2 Deep	07/20/1994	7.0	0.8	----	3.0	3.7	23.2
2 Deep	07/27/1994	8.0	----	----	----	----	----
2 Deep	08/03/1994	7.2	0.6	----	3.0	3.5	22.3

2	Deep	08/16/1994	7.0	0.9	----	3.0	3.5	19.8
2	Deep	08/24/1994	8.2	----	----	----	----	----
2	Deep	08/30/1994	6.5	0.9	----	2.8	3.1	17.2
2	Deep	09/05/1994	6.5	----	----	----	----	----
2	Deep	09/14/1994	7.8	----	4.6	----	----	----
2	Deep	09/28/1994	8.0	1.6	----	3.1	3.5	14.6
3	Center	06/09/1994	7.0	----	----	----	----	----
3	Center	06/15/1994	6.7	1.0	----	3.1	3.8	23.2
3	Center	06/22/1994	6.5	1.4	----	3.2	3.5	25.8
3	Center	06/30/1994	5.9	----	----	----	----	----
3	Center	07/06/1994	7.8	0.9	----	3.0	3.4	24.1
3	Center	07/14/1994	7.6	----	----	----	----	----
3	Center	07/20/1994	7.0	0.8	----	3.0	3.5	21.5
3	Center	07/27/1994	8.5	----	----	----	----	----
3	Center	08/03/1994	7.1	0.7	----	2.9	3.4	18.9
3	Center	08/16/1994	7.0	0.8	----	2.8	3.3	20.6
3	Center	08/24/1994	7.8	----	----	----	----	----
3	Center	08/31/1994	6.3	0.9	----	2.7	3.2	24.9
3	Center	09/05/1994	5.8	----	----	----	----	----
3	Center	09/14/1994	8.2	----	3.4	----	----	----
3	Center	09/28/1994	10.1	1.6	----	3.1	3.5	13.7
4	East	06/15/1994	-2.0	1.1	----	3.1	3.6	26.6
4	East	06/22/1994	5.5	1.2	----	3.0	3.5	30.1
4	East	06/30/1994	5.0	----	----	----	----	----
4	East	07/06/1994	-2.0	1.4	----	3.1	3.6	29.2
4	East	07/14/1994	5.8	----	----	----	----	----
4	East	07/20/1994	-2.0	1.4	----	2.9	3.6	24.1
4	East	07/27/1994	-2.0	----	----	----	----	----
4	East	08/03/1994	-2.0	0.9	----	3.0	3.5	24.1
4	East	08/16/1994	-2.0	1.0	----	2.9	3.3	20.6
4	East	08/24/1994	5.7	----	----	----	----	----
4	East	08/31/1994	-2.0	1.1	----	2.9	3.3	24.1
4	East	09/05/1994	5.3	----	----	----	----	----
4	East	09/14/1994	-2.0	----	5.8	----	----	----
4	East	09/28/1994	-2.0	1.4	----	3.0	3.4	18.0
5	North	06/09/1994	6.5	----	----	----	----	----
5	North	06/15/1994	7.0	1.3	----	3.0	3.7	26.6
5	North	06/22/1994	6.5	2.7	----	3.0	3.4	----
5	North	06/30/1994	6.1	----	----	----	----	----
5	North	07/06/1994	6.9	1.4	----	3.0	3.6	22.3
5	North	07/14/1994	7.0	----	----	----	----	----
5	North	07/20/1994	7.0	1.1	----	3.0	3.6	24.1
5	North	07/27/1994	7.0	----	----	----	----	----
5	North	08/03/1994	5.8	0.8	----	3.0	3.6	20.6
5	North	08/16/1994	6.5	1.0	----	3.0	3.3	19.8
5	North	08/24/1994	6.3	----	----	----	----	----
5	North	08/30/1994	6.5	1.1	----	2.8	3.2	19.8
5	North	09/05/1994	5.4	----	----	----	----	----
5	North	09/14/1994	7.5	----	3.1	----	----	----
5	North	09/28/1994	7.5	1.9	----	2.9	3.4	15.5
7	NorthIs	06/15/1994	5.0	1.4	----	3.0	3.9	36.9
7	NorthIs	06/22/1994	4.5	1.5	----	2.9	3.6	25.8
7	NorthIs	06/30/1994	5.0	----	----	----	----	----
7	NorthIs	07/06/1994	6.2	1.4	----	3.1	3.5	23.2

7 NorthIs	07/14/1994	5.8	----	----	----	----	----
7 NorthIs	07/20/1994	5.9	1.0	----	3.0	3.6	22.3
7 NorthIs	07/27/1994	5.6	----	----	----	----	----
7 NorthIs	08/03/1994	4.7	1.1	----	3.0	3.5	21.5
7 NorthIs	08/16/1994	5.5	0.8	----	3.0	3.3	21.5
7 NorthIs	08/24/1994	6.4	----	----	----	----	----
7 NorthIs	08/30/1994	5.7	1.3	----	2.8	3.2	23.2
7 NorthIs	09/05/1994	5.4	----	----	----	----	----
7 NorthIs	09/14/1994	7.6	----	5.8	----	----	----
7 NorthIs	09/28/1994	7.2	1.6	----	2.9	3.6	15.5
8 ForestI	04/22/1994	----	----	5.1	----	----	----
CooksInl	04/22/1994	----	----	4.6	----	----	----
DeerRvr	04/22/1994	----	----	7.9	----	----	----

<< End of 1994 listing, 91 records >>

Historical Lay Monitor Secchi Disk Data (1983-1994)

Lake	Site	Year	Minimum Secchi Disk Depth (meters)	Average Secchi Disk Depth (meters)	Maximum Secchi Disk Depth (meters)	Sample Size
Silver	1 South	1983	6.3	7.2	8.9	10
Silver	1 South	1984	4.3	5.7	6.8	16
Silver	1 South	1985	5.5	7.6	9.8	16
Silver	1 South	1986	5.8	6.9	8.0	16
Silver	1 South	1987	5.7	7.2	8.6	11
Silver	1 South	1988	5.5	7.3	8.8	15
Silver	1 South	1989	5.2	6.7	7.5	12
Silver	1 South	1990	4.6	6.4	8.5	12
Silver	1 South	1991	5.0	6.9	9.1	15
Silver	1 South	1992	6.2	7.3	8.7	14
Silver	1 South	1993	5.5	7.7	9.5	12
Silver	1 South	1994	5.5	7.4	9.0	15
Silver	2 Deep	1983	6.5	7.4	8.8	10
Silver	2 Deep	1984	4.0	5.6	6.7	16
Silver	2 Deep	1985	6.0	7.5	9.8	16
Silver	2 Deep	1986	6.0	6.8	7.8	16
Silver	2 Deep	1987	4.6	6.9	8.5	11
Silver	2 Deep	1988	6.1	7.4	9.1	15
Silver	2 Deep	1989	5.5	6.5	7.8	12
Silver	2 Deep	1990	4.0	6.3	8.3	12
Silver	2 Deep	1991	5.8	7.0	8.5	15
Silver	2 Deep	1992	6.2	7.5	9.5	14
Silver	2 Deep	1993	5.8	7.6	9.0	11
Silver	2 Deep	1994	6.5	7.2	8.2	15
Silver	3 Center	1983	6.2	7.5	8.5	10
Silver	3 Center	1984	4.1	5.5	6.8	16
Silver	3 Center	1985	6.0	7.7	9.8	16
Silver	3 Center	1986	5.4	6.4	7.4	16
Silver	3 Center	1987	5.8	7.0	8.5	11
Silver	3 Center	1988	6.0	7.2	8.5	15
Silver	3 Center	1989	4.5	6.3	7.5	12
Silver	3 Center	1990	4.4	6.3	8.4	12
Silver	3 Center	1991	5.1	7.0	8.5	15
Silver	3 Center	1992	6.2	7.3	8.5	13
Silver	3 Center	1993	5.8	7.6	9.4	11
Silver	3 Center	1994	5.8	7.3	10.1	15
Silver	4 East	1983	5.5	5.6	5.6	2
Silver	4 East	1984	4.2	4.9	5.5	12
Silver	4 East	1985	5.0	5.4	5.6	3
Silver	4 East	1986	4.5	5.2	6.0	9
Silver	4 East	1987	5.3	5.5	5.7	6
Silver	4 East	1988	4.8	5.6	5.8	15
Silver	4 East	1989	4.7	5.3	5.8	9
Silver	4 East	1990	4.0	4.9	5.5	5
Silver	4 East	1991	5.2	5.5	5.7	3
Silver	4 East	1992	5.7	5.7	5.7	1
Silver	4 East	1993	5.4	5.5	5.5	3
Silver	4 East	1994	5.0	5.5	5.8	5
Silver	5 North	1983	5.9	6.7	8.3	10
Silver	5 North	1984	4.2	5.2	6.6	16
Silver	5 North	1985	5.0	7.0	8.5	16
Silver	5 North	1986	4.8	6.0	7.2	17
Silver	5 North	1987	5.0	6.6	8.1	10
Silver	5 North	1988	5.8	6.9	8.5	15
Silver	5 North	1989	4.9	5.9	7.2	12
Silver	5 North	1990	4.3	5.9	7.4	12
Silver	5 North	1991	4.8	6.5	7.6	15
Silver	5 North	1992	5.5	6.7	9.5	14
Silver	5 North	1993	5.5	7.4	9.4	12
Silver	5 North	1994	5.4	6.6	7.5	15
Silver	7 NorthIs	1988	4.6	6.3	7.5	15
Silver	7 NorthIs	1989	5.0	5.7	7.1	12
Silver	7 NorthIs	1990	3.4	5.3	7.0	11
Silver	7 NorthIs	1991	4.6	6.4	7.7	15
Silver	7 NorthIs	1992	4.9	6.7	8.1	14
Silver	7 NorthIs	1993	4.5	6.7	7.5	11
Silver	7 NorthIs	1994	4.5	5.8	7.6	14

Historical Lay Monitor Chlorophyll a Data (1983-1994)

Lake	Site	Year	Minimum Chloro-phyll *a* (ppb)	Average Chloro-phyll *a* (ppb)	Maximum Chloro-phyll *a* (ppb)	Sample Size
Silver	1 South	1983	0.3	0.7	1.1	10
Silver	1 South	1984	0.6	1.1	1.6	15
Silver	1 South	1985	0.3	0.7	1.7	16
Silver	1 South	1986	0.4	1.0	1.8	16
Silver	1 South	1987	0.6	1.3	2.6	11
Silver	1 South	1988	0.6	1.4	2.4	15
Silver	1 South	1989	0.1	1.2	2.1	12
Silver	1 South	1990	0.9	1.4	1.9	12
Silver	1 South	1991	0.7	1.1	1.7	14
Silver	1 South	1992	0.6	1.2	1.9	14
Silver	1 South	1993	0.6	1.0	1.4	12
Silver	1 South	1994	0.6	1.1	1.6	8
Silver	2 Deep	1983	0.3	0.8	1.4	10
Silver	2 Deep	1984	0.3	1.0	1.9	14
Silver	2 Deep	1985	0.3	0.7	1.8	15
Silver	2 Deep	1986	0.4	1.1	2.1	16
Silver	2 Deep	1987	0.7	1.5	2.8	11
Silver	2 Deep	1988	0.6	1.4	3.1	15
Silver	2 Deep	1989	0.9	1.4	2.5	12
Silver	2 Deep	1990	1.0	1.4	2.2	12
Silver	2 Deep	1991	0.6	1.3	2.6	14
Silver	2 Deep	1992	0.6	1.1	1.9	14
Silver	2 Deep	1993	0.5	0.9	1.6	11
Silver	2 Deep	1994	0.6	1.0	1.6	8
Silver	3 Center	1983	0.3	0.8	1.2	10
Silver	3 Center	1984	0.6	1.1	1.9	14
Silver	3 Center	1985	0.2	0.6	1.6	15
Silver	3 Center	1986	0.4	1.1	2.1	16
Silver	3 Center	1987	0.4	1.2	2.0	11
Silver	3 Center	1988	0.7	1.3	2.4	15
Silver	3 Center	1989	0.1	1.3	2.4	12
Silver	3 Center	1990	0.9	1.4	2.1	12
Silver	3 Center	1991	0.6	1.1	1.9	14
Silver	3 Center	1992	0.4	1.0	1.7	14
Silver	3 Center	1993	0.4	1.0	1.7	12
Silver	3 Center	1994	0.7	1.0	1.6	8
Silver	4 East	1983	0.3	0.7	1.0	10
Silver	4 East	1984	0.5	1.2	2.4	14
Silver	4 East	1985	0.1	0.7	1.6	14
Silver	4 East	1986	0.1	1.1	2.0	16
Silver	4 East	1987	0.3	1.3	2.3	11
Silver	4 East	1988	1.1	2.0	7.8	15
Silver	4 East	1989	0.9	1.6	2.8	12
Silver	4 East	1990	1.2	1.6	2.7	12
Silver	4 East	1991	0.7	1.7	4.1	14
Silver	4 East	1992	0.9	1.2	2.1	13
Silver	4 East	1993	0.3	1.1	2.3	11
Silver	4 East	1994	0.9	1.2	1.4	8
Silver	5 North	1983	0.4	0.8	1.1	10
Silver	5 North	1984	0.6	1.4	3.0	14
Silver	5 North	1985	0.2	0.8	1.6	16
Silver	5 North	1986	0.4	1.3	4.1	17
Silver	5 North	1987	1.0	1.7	2.9	10
Silver	5 North	1988	1.1	1.6	3.1	15
Silver	5 North	1989	0.9	1.4	2.6	12
Silver	5 North	1990	1.4	1.8	3.0	12
Silver	5 North	1991	0.7	1.2	1.6	14
Silver	5 North	1992	0.4	1.3	1.8	14
Silver	5 North	1993	0.8	1.2	2.1	12
Silver	5 North	1994	0.8	1.4	2.7	8
Silver	7 NorthIs	1988	1.0	1.6	2.1	14
Silver	7 NorthIs	1989	1.0	1.4	2.0	12
Silver	7 NorthIs	1990	1.4	1.8	2.2	11
Silver	7 NorthIs	1991	0.9	1.2	1.6	14
Silver	7 NorthIs	1992	0.9	1.4	2.1	14
Silver	7 NorthIs	1993	0.9	1.3	1.8	11
Silver	7 NorthIs	1994	0.8	1.3	1.6	8

Silver Lake - Site 2 Deep (FBG data) AUG-10-1994

Depth (meters)	Chlorophyll *a* (ppb)	Color (ptu)	Total phos. (ppb)	SPCD (uS)	pH	CO_2 (mg/l)	Alk Gray end pt.	Alk Pink end pt.
0-5.5	1.4	14.6	12.6	32.8	6.4	0.8	2.6	3.0
0.5	1.4	16.3	----	32.5	6.4	0.8	2.7	3.1
3.0	----	----	----	32.6	6.4	0.5	2.1	2.5
6.5	2.5	18.9	----	32.4	6.4	0.8	2.6	3.0
20.0	----	----	5.6	32.5	6.2	2.7	2.1	2.5

Secchi Disk Depth = 6.8 meters

Depth (meters)	Temperature (°C)	Diss. oxygen (mg/l)
0.10	24.0	8.2
0.50	24.0	8.1
1.00	24.0	8.1
6.00	20.1	9.7
6.50	16.8	11.0
7.00	14.7	10.6
7.50	12.1	10.1
8.00	10.8	10.1
8.50	10.3	10.1
9.00	9.8	9.9
9.50	9.3	9.5
10.00	9.1	9.6
11.00	8.6	9.5
12.00	8.2	9.5
13.00	7.8	9.7
14.00	7.7	9.4
15.00	7.6	9.4
16.00	7.5	9.3
17.00	7.4	9.4
18.00	7.3	9.4
19.00	7.2	9.4
20.00	7.1	9.0
21.00	7.0	9.0
21.50	6.9	9.0
22.00	6.9	9.1
23.00	6.7	9.2
24.00	6.6	9.2

Depth (meters)	Temperature (°C)	Diss. oxygen (mg/l)
25.00	6.6	9.2
26.00	6.5	9.1
27.00	6.5	9.1
28.00	6.5	----

Silver Lake - Site 5 North (FBG data) AUG-10-1994

Depth (meters)	Chlorophyll *a* (ppb)	Color (ptu)	Total phos. (ppb)	SPCD (uS)	pH	CO_2 (mg/l)	Alk Gray end pt.	Alk Pink end pt.
0-4.0	1.9	12.9	6.1	33.2	6.4	1.0	2.7	3.0
0.5	1.5	12.9	----	32.5	6.3	0.6	2.7	3.1
2.0	----	----	----	33.0	6.4	0.9	2.7	3.0
6.0	3.1	16.3	----	32.7	6.2	0.9	2.4	2.7
16.0	----	----	8.7	33.3	6.2	3.3	2.2	2.6

Secchi Disk Depth = 6.5 meters

Depth (meters)	Temperature (°C)	Diss. oxygen (mg/l)
.0.10	25.2	8.1
1.00	25.1	8.2
2.00	25.1	8.1
3.00	24.5	8.2
4.00	24.0	8.2
4.50	23.1	8.5
5.00	22.3	8.9
5.50	21.0	9.5
6.00	17.4	10.4
6.50	15.4	10.4
7.00	13.9	9.5
7.50	12.8	9.7
8.00	11.9	9.7
8.50	10.8	9.6
9.00	10.3	9.6
10.00	9.2	9.4
11.00	8.8	9.1
12.00	8.7	9.1
13.00	8.6	8.6
14.00	8.4	8.3
15.00	8.4	8.1
16.00	8.3	7.0
17.00	8.2	6.4

Silver Lake - Site 7 North Island (FBG data) AUG-10-1994

Depth (meters)	Chlorophyll *a* (ppb)	Color (ptu)	Total phos. (ppb)	SPCD (uS)	pH	CO_2 (mg/l)	Alk Gray end pt.	Alk Pink end pt.
0-5.0	1.9	18.9	6.6	34.0	6.4	0.8	2.9	3.3
0.5	1.6	14.6	----	33.3	6.4	0.7	2.7	3.1
3.0	----	----	----	32.9	----	1.7	2.2	2.6
6.0	2.6	17.2	5.1	34.3	6.4	0.9	2.8	3.2
10.0	----	----	15.0	33.8	5.9	6.6	2.3	2.6

Secchi Disk Depth = 6.7 meters

Depth (meters)	Temperature (°C)	Diss. oxygen (mg/l)
0.10	25.4	8.1
1.00	25.3	8.2
2.00	25.1	8.3
3.00	24.2	8.5
4.00	23.6	8.4
4.50	23.4	8.5
5.00	23.0	8.5
5.50	21.3	9.0
6.00	18.2	10.2
6.50	15.6	9.8
7.00	13.8	9.2
7.50	12.7	8.5
8.00	11.6	6.2
8.50	10.5	4.9
9.00	9.5	2.5
9.50	9.0	0.8
10.00	8.5	0.1
10.50	8.2	0.0
11.00	8.0	0.0

APPENDIX B

GLOSSARY OF LIMNOLOGICAL TERMS

Aerobe- Organisms requiring oxygen for life. All animals, most algae and some bacteria require oxygen for respiration.

Algae- See phytoplankton.

Alkalinity- Total concentration of bicarbonate and hydroxide ions (in most lakes).

Anaerobe- Organisms not requiring oxygen for life. Some algae and many bacteria are able to respire or ferment without using oxygen.

Anoxic- A system lacking oxygen, therefore incapable of supporting the most common kind of biological respiration, or of supporting oxygen-demanding chemical reactions. The deeper waters of a lake may become anoxic if there are many organisms depleting oxygen via respiration, and there is little or no replenishment of oxygen from photosynthesis or from the atmosphere.

Benthic- Referring to the bottom sediments.

Bacterioplankton- Bacteria adapted to the "open water" or "planktonic" zone of lakes, adapted for many specialized habitats and include groups that can use the sun's energy (phytoplankton), some that can use the energy locked in sulfur or iron, and others that gain energy by decomposing dead material.

Bicarbonate- The most important ion (chemical) involved in the buffering system of New Hampshire lakes.

Buffering- The capacity of lakewater to absorb acid with a minimal change in the pH. In New Hampshire the chemical responsible for buffering is the bicarbonate ion. (See pH.)

Chloride- One of the components of salts dissolved in lakewater. Generally the most abundant ion in New Hampshire lakewater, it may be used as an indicator of raw sewage or of road salt.

Chlorophyll a- The main green pigment in plants. The concentration of chlorophyll *a* in lakewater is often used as an indicator of algal abundance.

Circulation- The period during spring and fall when the combination of low water temperature and wind cause the water column to mix freely over its entire depth.

Density- The weight per volume of a substance. The more dense an object, the heavier it feels. Low-density liquids will float on higher-density liquids.

Dimictic- The thermal pattern of lakes where the lake circulates, or mixes, twice a year. Other patterns such as polymictic (many periods of circulation per year) are uncommon in New Hampshire. (See also meromictic and holomictic).

Dystrophy- The lake trophic state in which the lakewater is highly stained with humic acids (reddish brown or yellow stain) and has low productivity. Chlorophyll *a* concentration may be low or high.

Epilimnion- The uppermost layer of water during periods of thermal stratification. (See lake diagram).

Eutrophy- The lake trophic state in which algal production is high. Associated with eutrophy is low Secchi disk depth, high chlorophyll *a*, and high total phosphorus. From an esthetic viewpoint these lakes are "bad" because water clarity is low, aquatic plants are often found in abundance, and cold-water fish such as trout and salmon are usually not present. A good aspect of eutrophic lakes is their high productivity in terms of warm-water fish such as bass, pickerel, and perch.

Free CO2- Carbon dioxide that is not combined chemically with lake water or any other substances. It is produced by respiration, and is used by plants and bacteria for photosynthesis.

Holomixis- The condition where the entire lake is free to circulate during periods of overturn. (See meromixis.)

Humic Acids- Dissolved organic compounds released from decomposition of plant leaves and stems. Humic acids are red, brown, or yellow in color and are present in nearly all lakes in New Hampshire. Humic acids are consumed only by fungi, and thus are relatively resistant to biological decomposition.

Hydrogen Ion- The "acid" ion, present in small amounts even in distilled water, but contributed to rain-water by atmospheric processes, to ground-water by soils, and to lakewater by biological organisms and sediments. The active component of "acid rain". See also "pH" the symbolic value inversely and exponentially related to the hydrogen ion.

Hypolimnion- The deepest layer of lakewater during periods of thermal stratification. (See lake diagram)

Lake- Any "inland" body of relatively "standing" water. Includes many synonyms such as ponds, tarns, loches, billabongs, bogs, marshes, etc.

Lake Morphology- The shape and size of a lake and its basin.

Littoral- The area of a lake shallow enough for submerged aquatic plants to grow.

Meromixis-The condition where the entire lake fails to circulate to its deepest points; caused by a high concentration of salt in the deeper waters, and by peculiar landscapes (small deep lakes surrounded by hills and/or forests. (Contrast holomixis.)

Mesotrophy- The lake trophic state intermediate between oligotrophy and eutrophy. Algal production is moderate, and chlorophyll *a*, Secchi disk depth, and total phosphorus are also moderate. These lakes are esthetically "fair" but not as good as oligotrophic lakes.

Metalimnion- The "middle" layer of the lake during periods of summer thermal stratification. Usually defined as the region where the water temperature changes at least one degree per meter depth. Also called the thermocline.

Mixis- Periods of lakewater mixing or circulation.

Mixotrophy- The lake condition where the water is highly stained with humic acids, but algal production and chlorophyll *a* values are also high.

Oligotrophy- The lake trophic state where algal production is low, Secchi disk depth is deep, and chlorophyll *a* and total phosphorus are low. Esthetically these lakes are the "best" because they are clear and have a minimum of algae and aquatic plants. Deep oligotrophic lakes can usually support cold-water fish such as lake trout and land-locked salmon.

Overturn- See circulation or mixis

pH- A measure of the hydrogen ion concentration of a liquid. For every decrease of 1 pH unit, the hydrogen ion concentration increases 10 times. Symbolically, the pH value is the "negative logarithm" of the hydrogen ion concentration. For example, a pH of 5 represents a hydrogen ion concentration of 10^{-5} molar. [Please thank the chemists for this lovely symbolism -- and ask them to explain it in lay terms!] In any event, the higher the pH value, the lower the hydrogen ion concentration. The range is 0 to 14, with 7 being neutral 1 denoting high acid condition and 14 denoting very basic condition.

Photosynthesis- The process by which plants convert the inorganic substances carbon dioxide and water into organic glucose (sugar) and oxygen using sunlight as the energy source. Glucose is an energy source for growth, reproduction, and maintenance of almost all life forms.

Phytoplankton- Microscopic algae which are suspended in the "open water" zone of lakes and ponds. A major source of food for zooplankton. Common examples include: diatoms, euglenoids, dinoflagellates, and many others. Usually included are the blue-green bacteria.

Parts per million- Also known as "ppm". This is a method of expressing the amount of one substance (solute) dissolved in another (solvent). For example, a solution with 10 ppm of oxygen has 10 pounds of oxygen for every 999,990 pounds (500 tons) of water. Domestic sewage usually contains from 2 to 10 ppm phosphorus.

Parts per billion-Also known as "ppb". This is only 1/1000 of ppm, therefore much less concentrated. As little as 1 ppb of phosphorus will sustain growth of algae. As little as 10 ppb phosphorus will cause algal blooms! Think of the ratio as 1 milligram (1/28000 of an ounce) of phosphorus in 25 barrels of water (55 gallon drums)! Or, 1 gallon of septic waste diluted into 10,000 gallons of lake-water. It adds up fast!

Plankton- Community of microorganisms that live suspended in the water column, not attached to the bottom sediments or aquatic plants. See also "bacterioplankton" (bacteria), "phytoplankton" (algae) and "zooplankton" (microcrustaceans and rotifers).

Saturated- When a solute (such as water) has dissolved all of a substance that it can. For example, if you add table salt to water, a point is reached where any additional salt fails to dissolve. The water is then said to be saturated with table salt. In lakewater, gaseous oxygen can dissolve, but eventually the water becomes saturated with oxygen if exposed sufficiently long to the atmosphere or another source of oxygen.

Specific Conductivity- A measure of the amount of salt present in lakewater. As the salt concentration increases, so does the specific conductivity (electrical conductivity).

Stratum- A layer or "blanket". Can be used to refer to one of the major layers of lakewater such as the epilimnion, or to any layers of organisms or chemicals that may be present in a lake.

Thermal Stratification- The process by which layers are built up in the lake due to heating by the sun and partial mixing by wind.

Thermocline- Region of temperature change. (See metalimnion.)

Total Phosphorus- A measure of the concentration of phosphorus in lake-water. Includes both free forms (dissolved), and chemically combined form (as in living tissue, or in dead but suspended organisms).

Trophic Status- A classification system placing lakes into similar groups according to their amount of algal production. (See Oligotrophy, Mesotrophy, Eutrophy, Mixotrophy, and Dystrophy for definitions of the major categories)

Z- A symbol used by limnologists as an abbreviation for depth.

Zooplankton- Microscopic animals in the planktonic community. Some are called "water fleas", but most are known by their scientific names. Scientific names include: *Daphnia*, *Cyclops*, *Bosmina*, and *Kellicottia*.